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A Centralized Power Plant.

The new power plant of Walter Baker & Co., Ltd., described elsewhere in this issue, is a capital type of the recent tendencies toward economic power production in large manufacturing plants. In earlier days, when most manufacturing was conducted on a modest scale, and electrical transmission was unknown, engineers vied with each other in laying out imposing engine rooms from which power was distributed by carefully planned systems of belts and shafts. In a well-planned building of not too great size and in works where the load conditions were favorable, such installations did, and now and then continue to do, very excellent work. Some of the New England mill plants have managed to deliver wonderfully reliable and cheap power in spite of rather costly fuel. As a works grows, however, new buildings have to be put up and eventually a time comes when, looked at as a whole, big buildings and small, the system of individual engine rooms is very uneconomical. On a large scale power gains in economy of production by the higher efficiency of big units and by the very considerable saving in labor. The small boiler and engine rooms certainly require an abnormal amount of attention and cost far more per horse-power initially than does a larger installation. The advent of the electric motor has made consolidation possible, with all its gain in cheaper production, and in these days the saving of power lost in long line shafts goes far toward paying for the larger expenditure at the start.

The Walter Baker plant seems especially well suited to show the economies of electric distribution, since it consists of a considerable group of buildings, none of them requiring power enough to make it easy to install a highly economical plant, yet altogether demanding an output sufficient to ensure a large saving in cost of power. Of the well-known incidental advantages of electric power it is unnecessary to speak here, save to say that the gain in facility of operation and in power saved from the shafting is enough to justify a change. The present plant is interesting as showing an adherence to conservative methods that will bear serious consideration. The boiler plant is of vertical fire tube units. These have been largely used in mill practice and in spite of the competition of water-tube boilers have fully held their own in economical steam generation when properly handled. With careful firing they are probably capable of furnishing steam, including allowance for investment and up-keep, at least as cheaply as any of their competitors. In connection with the flue system are installed economizers and reheaters for the steam in the intermediate stage of its use. With internally-fired boilers and these heat-saving devices the outlook for high efficiency would seem to be excellent. The stoking is entirely by hand, which, with relatively high-grade fuel, such as is commonly used about Boston, generally gives good economic results, the tests of the Boston Elevated Ry. in its several stations having shown that the difference in cost of power with hand and machine stoking is very small, and obviously the abolition of mechanical stokers makes a considerable difference in first cost.

As it is with the boilers so it is with the generating sets. In spite of the fact that three-phase current is used, the engine room contains vertical cross-compound engines with rather high rotative speed and worked in connection with ample surface condensers. The only trace of steam turbine practice is found in the exciting sets which so far as the steam-driven ones are concerned, are turbo-generators. Of course all this is very heterodox, from the standpoint of those who exploit turbines, and the engineer of the plant must expect to be scored as a violent reactionary. Yet he laughs best who laughs last, and it will be very interesting to see the results of a couple of years' run of this plant compared with those from the latest fashionable style of turbine plant with water-tube boilers, automatic stokers and all the other fixings thereunto appertaining. It would also be interesting to know the first cost of this thoroughly well built and substantial power plant as compared with a typical turbine plant of the same capacity. The purpose of a modern central power plant is not to demonstrate engineering thesis, but to furnish power at the lowest possible cost, including interest and up-keep, and with the utmost possible degree of reliability. One cannot afford to take chances with continuity of service when trouble means shutting down a big industrial plant, and it seems certain that this particular plant is likely to make a good record, both in reliability and economy. It is a thoroughly well designed plant following lines of long proved success, and when the operating balance sheet is struck it should be a very favorable one. It is to be hoped that the results will be made public, for there are now few power stations built of the kind in which the latest and best forms of the conservative type of equipment are combined in a thoroughly constructed and well-planned system.

Contract Methods for Doing Work.

There are a number of ways of accomplishing the main purposes of any contract for large work frequently of practically equal excellence when followed by competent and experienced contractors, especially if prior experience indicates a use of those methods. This is not saying that the various ways by which a given piece of construction can be accomplished will always lead to equally good results from any one contractor. A contractor who has satisfactorily accomplished a given piece of construction will naturally be inclined to follow the same procedures in any subsequent construction of the same general class or if it is more or less similar to that which he has already done. Moreover, two equally experienced and skillful contractors may entertain widely different views as to the best methods to be followed in any specific contract, each being influenced by his prior experience. A large amount of masonry may have been put in place in the one instance by a given plant in which overhead cableways have constituted one of the main features if not the principal feature, while another contractor doing precisely the same work might prefer and insist upon the use of an entirely different style of plant in which derricks or derrick towers would be the main feature of his installation without any reference whatever to overhead equipment. This specific instance is indicative of good judgment which may be displayed with the greatest diversity corresponding to an equal diversity of work to be accomplished.

It frequently becomes a matter of special importance to the engineer in draughting specifications and contracts to decide to just what extent method or operations in the field shall be set forth in the written agreement under which work is to be executed. There have been cases perhaps more frequently in later practice than in the early history of large public works in this country in which certain features of field operations have been set forth in contracts in unqualified terms while others have been stated as alternatives to be displaced at the option of the contractor by others which must be shown to be of at least equal efficiency. In other contracts or possibly for other portions of the work under the same contract no methods of procedure have been specified, leaving the contractor free to exercise unqualifiedly his own judgment, results of given excellence only being demanded. The questions to be decided are, which of these forms of procedure shall be adopted in any given contract for large work and to what extent?

As a general proposition it is obvious that no precise instructions of broad scope can be laid down in such matters. Such questions must be treated largely if not entirely on their own merits in connection with any given contract, but there are certain considerations which should control most of the specifications or contract provisions of this class. It goes without saying that one of the main objects in securing a contractor to build any given work is to make the results of his skill and experience available in its construction. One of the first qualifications required of contractors who are to make tenders is prior experience in successful work and as much of it as possible. Any provisions of the specifications and contract, therefore, which tend to render unavailable such experience or skill are at least ill-considered and may be highly objectionable. This observation gains force when it is remembered, as has already been stated, that successful contractors not unfrequently develop quite different procedures for the accomplishment of practically the same ends and any attempt to make one of them follow precisely the processes or methods with which he is not familiar, even if they have been most successfully developed by other contractors, would defeat the very purposes of the contract provisions requiring such a procedure. Within the limits of efficiency of operation and excellence of final results it is not wise to prescribe methods of procedure too closely for such methods may or may not be those with which the successful bidder can accomplish his best results.

On the other hand it is absolutely essential that contract provisions should be so drawn as to permit no work to be done without clear assurance to the engineer that the methods to be followed are such as to secure efficiently the best possible results. There is a wide difference between a weak or inefficient indifference to construction methods and a rigidity of instructions which hamper by narrowness a contractor's operations. It is the business of the engineer to prescribe such a course as will guard the interests of his client on the one hand and give a reasonable and efficient freedom to the skill and energy of the contractor on the other.

These observations are of controlling importance when the exact character of all the work of construction covered by a contract can be clearly foreseen, but they gain greatly added force when as in most contracts for large work a considerable portion of the construction cannot be closely predetermined. In such a case the character of procedures best adapted to accomplish the desired results will depend to some extent and sometimes almost entirely upon the developments attending actual construction. The significance of the resulting conditions cannot be completely ascertained until disclosed by the progress of the contract work. Under such circumstances it is imperative that provision be made in the contract for such adjustment of procedures as will best meet the exigencies of the work. While it is obvious that the least possible number of questions should be left unsolved in preparing the specifications and contract it is a necessity which cannot be evaded to cover the undetermined conditions with general provisions sufficiently well defined to enable a contractor to estimate his costs with reasonable certainty, but with sufficient freedom of application to meet every disclosure of the work in progress.

Power Plant Tests by Engineering Students

The modern power plant in commercial service offers such an attractive opportunity to the engineering student in the way of thesis investigations that it is not surprising a considerable amount of such work is in progress this year in the vicinity of technical schools. The steam-driven station has for many years been the theme of undergraduate analyses of its performance in the way of fuel and water consumption, and the more recent developments of the turbine plant and the gas engine power installation have done much to quicken the interest of both teachers and students in the economical generation of power. The very fact that the prime-mover question is so unsettled seems to stimulate the desire of investigators to throw a little more light upon the uncertain phases of power plant performance, in the hope that data may be secured which will facilitate the choice of equipment in actual engineering practice.

There is not the slightest doubt that a test of a commercial plant may be made a valuable experience of the undergraduate student, and if properly carried out and interpreted the results ought to be useful to the company operating the station. But if the work is done in the shipshod manner which has sometimes been the case, the effect upon the students bids fair to be demoralizing and the figures obtained of absolutely no value to the company. There are many pitfalls for the unwary in dealing with so many and variable quantities as enter the process of power production in every station depending upon fuel consumption as the basis of the generating cycle. Directly or indirectly all such tests cost an operating company something, through the necessary interference with routine output, the probable consumption of extra supplies and need of extra labor in preparing platforms, water barrels, special piping and wiring. Then there is the ever-present possibility of some accident to the equipment and the possible interruption of service through some blunder of a thoughtless observer. These points make it doubly essential that the work shall be done in a careful manner, as a return for the courtesy of turning the station into a laboratory on a great scale for the benefit of the embryo engineer.

Expert supervision is absolutely essential in test work of this character. Whether the responsible head of the test be one of the engineering professors, an experienced instructor or a consulting engineer, a representative of the operating company who is thoroughly posted regarding the daily operation of the plant should be constantly on hand to see that the regular output of the station is not cut short and to give the benefit of his familiarity with the individual machines, piping, wiring and other details to the testing party. In some tests made this year in connection with thesis work, there has been a lack of expert supervision that has gone far to render the results of little value. The practice of leaving a party of students in sole charge of a test on a plant, even temporarily, is disadvantageous from the standpoints of both company and educational scheme. However accustomed a student may be to laboratory methods, to the accurate reading of instruments and the manipulation of rheostats, switches and valves, it is practically impossible for men without routine experience in commercial power plants to get the business point of view in making these tests on a large scale. It is hard for students to realize that an arithmetical mistake in recording the weight of fuel or water used, or in subtracting the consecutive readings of switchboard wattmeters, utterly invalidates the results of the test. The excessive tendency of modern educators to lay stress upon methods rather than results from the kindergarten up, finds its fruition in the blundering computations and sleazy phraseology of some of these test reports. The ability of a student to determine by the calculus the distance a horse will walk in unwinding a few coils of taut rope from a post in no sense compensates for mistakes in simple addition and subtraction in putting down the results of a power plant test.

Given the sense of proportion and the appreciation of practical limits of accuracy possessed by an experienced executive observer, careful checking of readings and computations, full co-operation between the testing party and the company's representatives, the calibration of apparatus and a hammered-in conviction on the part of each observer that a numerical error is to be shunned like a pestilence, the test of a power plant by a group of mature students ought to have a definite value for interpretation. The study of the data secured should give the company useful and suggestive information as to the physical quantities involved in the manufacture of its power, the behavior of apparatus under definite conditions and possible sources of improvement. The cost of making such a test is greatly reduced by the absence of any necessity of paying for the services of the observers. Whether the immediate supervision should be by the company's own staff or by its consulting engineer is a matter to be settled by local conditions. It is scarcely necessary to point out that the interpretation of test results is precisely as important a matter as the actual securing of the figures and diagrams from which conclusions are to be drawn. The contact which the engineering student receives at such times with the concrete installation and with the human element in the power house service is worth all it costs in soiled hands, reddened faces and overtaxed patience when things go wrong. It is a very different matter to sit in an easy chair with a fountain pen and a pad in one's hands and figure comfortably the number of gallons of oil which a given duplex pump will deliver at a definite speed in comparison with the annoyance of having to contend with a leaky valve in the small hours of the morning and keep the flow as constant as possible amid the discomforts of a low basement packed full of condensing apparatus and hot pipes. If the futility of excuses is learned by every college man in a power plant test; if the difference between a simple blackboard diagram and an actual layout of pipes and wires where space is cramped becomes appreciated and if the high technical misdemeanor of a numerical error is sensed the work is well worth while, even though no new and striking facts be detected in regard to the desirable design of modern equipment. An operating company can well afford to encourage studies of this kind if they are undertaken in the general spirit outlined in these comments.

The Engineering Societies' Building.

The dedication of the Engineering Societies' Building on Tuesday and Wednesday of this week was an event which all engineers, irrespective of their special branches of work, will agree means a great deal for the profession and its standing in the community. The handsome structure which has been opened to the engineering profession on Thirty-ninth St. in New York is something more than a house for the libraries of various societies and offices for their staffs. It symbolizes to those who see it the essential unity of purpose of the various branches of engineering and the importance which they have already attained in the community, but more than this it is an incentive for mutual co-operation in advancing engineering interests everywhere. Not the least of its advantages is its generous plan of providing a home for all of the minor engineering and scientific organizations which up to the present time have been living precariously wherever desk room or a small office could be obtained. This new headquarters for engineering will, therefore, also be in a measure a headquarters for various branches of applied science and the relation between science and engineering will thus be emphasized. It is reasonable to expect, therefore, that with careful management the Engineering Societies' Building will become a headquarters not only for engineers, like the commodious and attractive building of the American Society of Civil Engineers farther uptown, but also for those who take an interest in engineering as men of science or of business.

The construction and dedication of this building, however important they may be, are simply the first steps of a pretty severe trial of engineering societies and their official management. Up to the present time the work has been carried on largely through the assistance of Mr. Carnegie; from now forth will come the real trials of this project. It remains to be proved whether the three participating societies in Mr. Carnegie's gift will be able to live together in harmony and carry out the various plans which were originally suggested as warranting such a serious venture. The management of the new building calls for an annual expenditure of a very large amount, and this must be certainly provided for. None of the three societies which are primarily concerned in this building have made it a practice to pass the hat for funds. There is no reason, however, why they should not do this and urge their members to contribute according to their ability. It has been done in the American Society of Civil Engineers repeatedly; one of the reasons that the society is so financially strong at the present time is that it has never hesitated in the past to ask its members and wealthy people outside its list of membership for financial assistance. This is mentioned because it is to be hoped that the building will be placed immediately on a sound financial basis, so that there shall never in the future be any question on that score. The American Institute of Electrical Engineers is already in possession of funds ample to carry its share, and there is no reason to doubt the ability of the other organizations to raise whatever money is needed.

Apart from the financial obligations incurred in this splendid home for engineering, there are a number of technical and social obligations which must be met, and it is to be hoped that some announcement will shortly be made concerning the manner in which these will be carried out. It will be recalled that one of the arguments most frequently made for such a consolidated home was that a united effort would be made by the societies to form and conduct in their new building a large and comprehensive engineering library. To many of those who weighed the arguments for and against entering upon such a project, this great library was probably the deciding feature which led them to vote for the project. It is to be hoped that such a project will be carried out and instead of maintaining three little, relatively unimportant libraries, not particularly strong except in a few narrow specialities, a plan will be worked out by which a real library, useful for research and consultation by students as well as by the casual reader, will be established. At the present time the library of the American Society of Civil Engineers is unquestionably the only one in the city which is at all satisfactory for general engineering reference, but it does not pretend to be full, particularly in historical volumes, except in civil engineering. Accordingly there is a great opportunity in the new building to organize a really important general engineering library on the basis of the collections of the three national societies which have their headquarters there. Another feature of the argument made for entering upon this building project was that the housing of the three national societies and minor associations under one roof would lead to a closer affiliation of their various members. It is not yet known just how far plans have been prepared for accomplishing this very desirable object, but it is to be hoped that before long announcements will be made concerning union meetings of various societies and other indications of a close association of these organizations for the benefit of engineers, not only in New York but throughout the country.

The Tie Problem.

The valuable paper by Mr. Lincoln Bush, chief engineer of the Delaware, Lackawanna & Western R. R., which is printed elsewhere in this issue, is an excellent statement of the difficulties the tie problem presents to railways in the Eastern States. It is the first article that has appeared in a long time, if, indeed, it is not the only article, in which the financial aspect of the tie situation is discussed in detail and the possibilities of treating available woods for track purposes are considered in a business-like fashion for perfectly definite conditions. From the data accumulated at existing tie-treating plants the author figures out closely just about what the cost of ties of available timbers will be after treatment, in the northeastern part of the country. The information in the article is particularly interesting because it shows that before long at the present rate with which timber is being cut off, the railroads in the portion of the country mentioned will find it difficult to get good wood ties, even by treating so-called inferior timber. This situation has been predicted a number of times by engineers connected with the Forestry Service of the Government, but definite data pointing to the same conclusion have not been formulated before to such a close degree as by Mr. Bush in this article.

While this article and other statements on the same subject during recent years indicate that engineers will not have to lay awake nights worrying over cross ties for ten years or so to come, nevertheless the date is not much more distant when some relief will have to be furnished from a situation that is now reaching its culmination. A good many people have talked about the depletion of the cross-tie timber in a frivolous way, which shows an ignorance of what can be done by forestry and particularly of what cannot be done by it. Some of these people have stated that it was only necessary for the railroad companies to grow timber on waste land in the vicinity of their lines in order to secure all the ties they need from this time forward. Apparently these people think that it is as easy to make a forest grow as to raise a bed of asparagus, but those who are acquainted with the difficulties of forestry and with the long time which must elapse between the planting of seedlings and the cutting of timber know very well that the forestry enterprises which any railroad is justified in maintaining will supply only a small portion of the timber necessary for its track purposes. It is well known that a number of railroad companies have studied this problem rather carefully. Some of them, in fact, are maintaining plantations in order that they may know definitely what can be accomplished in the vicinity of their lines. While the results of these experiments have not been made public, it is understood that they are only partially encouraged. This bears out the predictions of people who have made a life-long study of forestry work.

Under such conditions it is probable that the engineers of the country must eventually turn to steel cross ties as a substitute for those of wood, at least in some portions of the country. Fifteen years or so ago there was a remarkable boom in this country over such ties, and every inventor who had a little time to spare turned his attention to the production of a steel cross tie. These designs were numerous and most of them wholly impracticable. For one reason or another the average conception of a cross tie seemed to be something that could be laid upon the ground without falling over from the position in which it was placed. The idea that it was necessary to have a tie that would remain firmly in place was apparently rarely recognized and few people had any idea that the attachment of the rail to the tie was the most difficult part of the whole problem. Experience indicates that while it is not troublesome to construct steel cross ties which will support the loads coming upon them, the problem that is difficult to solve in connection with their use is the best way of attaching the rails to them. The time has gone by when it is possible to say without incurring risk of immediate contradiction that metal ties are impracticable. As a matter of fact they are used on altogether too many railways under too many conditions of service for any such statement to have any standing among railway officials. The questions connected with their use in America are entirely apart from their practicability to carry the traffic. They relate to the practicability of methods of fastening the rails to the ties, so that under the enormously heavy loads which our American rolling stock imposes upon the tracks the latter will safely discharge its functions. The Engineering Record is of the opinion that there is hardly anything in the railroad field at the present time which offers such an opportunity for successful invention as the design of fastenings between steel ties and rails. The subject is a complicated one on account of the interest of powerful steel companies at present experimenting with metal ties, but there can be no question about its importance nor about the probability that fifteen or twenty years hence the manufacture of such ties will assume a position comparable in a considerable degree with the manufacture of steel rails. While there will always be branch lines and little jerkwater railroads carrying no traffic to speak of, which can utilize fence posts and other decrepit timber for ties, heavy traffic requiring thoroughly durable track construction will make the steel tie a very important factor in railroad construction.

A Special Appeal is made by The Engineering Record to its readers to assist the faculty of the School of Applied Science at McGill University in again gathering together a library, for the excellent collection formerly owned by this famous Montreal institution was completely destroyed in the recent fire which gutted Macdonald Hall. It needs no long argument to demonstrate that the library of such an influential school ought to possess all the important engineering reports that are issued by public authorities, and for this reason readers having copies of such reports which they can spare are urged to send them to Dr. Henry T. Bovey, dean of the faculty of applied science. This does not mean, however, that text-books and treatises on engineering and scientific subjects will not be equally welcome, for the fire completely destroyed this very valuable portion of the university's facilities. Most engineers accumulate a number of books they do not use, but are nevertheless valuable in a general library, and such volumes will be warmly welcomed by the McGill authorities.

Safety Against Accidents has been often discussed, but it has remained for the American Institute of Social Service to demonstrate how general is the belief among thoughtful people that concerted action to develop and introduce safeguards against accidents is very desirable. This organization was formed not long ago by Dr. Josiah Strong, Dr. Wm. H. Tolman and others whose work gave them an opportunity to recognize the extent of this feeling, and it has already been intrusted with the duty of awarding two gold prizes for inventions of a safety nature and an annual cash prize for the best essay on the subject of safeguarding life. The Institute is also arranging for a permanent exhibit of devices of this character and is formulating plans by which the experience gained in one direction may be utilized in others. The purpose of the Institute is one that deserves hearty support, particularly from employers of large numbers of working people. The enormous annual losses caused by preventable accidents warrant the belief that humanitarian motives and sound business policy will lead to an investigation of the work of this Institute by many of the readers of The Engineering Record. Dr. Tolman, whose address is 287 Fourth Avenue, New York, will be glad to furnish further particulars concerning the objects and plans of the organization.

TREATMENT OF RAILROAD TIES AND THE MATERIALS AVAILABLE FOR THIS PURPOSE IN NEW JERSEY, NEW YORK AND PENNSYLVANIA.

By L. Bush, Chief Engineer, Delaware, Lackawanna & Western R. R. Co.

In the New York market the price of hemlock in the past ten years has increased 90 per cent., white pine 95 per cent., Southern yellow pine 110 per cent., and the other timber materials extensively used have increased in a corresponding ratio, notwithstanding the material depreciation that has taken place in quality. The value of our present forest products per annum in the United States is nearly $1,000,000,000, and only 25 per cent. of the contents of the tree cut is converted into finished product. We are using in the United States nearly seven times as much timber per capita as is used in Europe.

It is estimated that between 115,000,000 and 120,000,000 ties are used annually in the United States for renewals and construction of steam railroads, and in addition to the requirements of the steam railroads, a very large number of ties are used annually in the maintenance and construction of electric roads. The native supply of white oak in the Northeastern States is nearly exhausted, and it is generally believed that the consumption of oak and yellow pine ties will very soon overtake and exceed the supply from the South, rendering the cost of first quality ties to Eastern roads almost prohibitive. A statement of these facts shows that the large users of our forest products, and the railroads in particular, are confronted with a situation that demands prompt, careful and serious consideration.

While experiments with steel and reinforced concrete are being made to discover a substitute for the wooden tie and many companies are planting rapid-growing trees in the attempt to provide for at least a part of their future consumption, it must now be conceded that it is necessary for the railroads to adopt and encourage proper methods of forestry and take immediate steps to conserve the fast diminishing timber supply [see R. R. Gaz., March 16, 1906, p. 243] until such time at least as some practical substitute is discovered and perfected, or until large artificial forests covering extensive areas are sufficiently matured to become available and thus relieve in a material degree the demolition of the natural forest. The most practical and feasible method of accomplishing this result is by means of the chemical treatment of timbers and ties and also by treating inferior woods, which are not now available for use as ties owing to their susceptibility to decay, so that these inferior woods at an equal or less cost may be made equal to the first-class untreated oak and yellow pine ties now used. Thus, if by treatment and at an equal cost, a red oak or a black oak tie is rendered the equal in term of service to a first-class untreated white oak tie, then nothing can be lost by such treatment and the timber supply is conserved. From an economic standpoint, we would be warranted in expending for the treatment of a tie a sum approximately equal to the first cost of the tie providing its life were doubled; because in so doing the cost of labor in maintenance would be reduced and the cost of one replacing would be eliminated and the supply of timber preserved, thereby reducing the future cost of ties.

The inevitable future increase in prices will modify the relations just stated and show much greater gains by treatment in the future. Another step in the right direction is the adoption of stone ballast, which not only increases the stability and smoothness of the track and lessens maintenance cost but also, because of better drainage, increases the life of a white oak tie by about 10 per cent. over that of the same tie laid in gravel ballast. In the same connection should also be mentioned the value of tie plates which, especially in the case of pine, chestnut and other varieties of the softer woods, increase materially the life of the tie in service and render available for track service some materials that could not otherwise be utilized. Admitting that it is necessary to conserve the timber supply to meet future requirements, it will be shown that the treating of ties in the States referred to, as a financial proposition, would be profitable under the present conditions of supply and demand, and will prove more so in the future with the ever diminishing supply and increasing demand.

The subject will be discussed under the following headings:

(1) Native timbers which are available.

(2) Best method of preparing these timbers for treatment.

(3) Methods and cost of treatment.

(4) Plant for treating ties.

Native Timbers Available.—In many of the forests of New Jersey, Pennsylvania and portions of New York are the following timbers, which are either suitable for ties without treatment or may be made suitable by treatment: White oak, chestnut, red oak, black oak, bull pine. These five varieties make up the bulk of the available native timber supply suitable for the purposes of treatment in the States noted.

Of these the white oak is the most durable, both as to resisting decay and the cutting from the rails, but does not take preservation as readily and as effectively as the inferior woods.

In a report made to the Bureau of Forestry in Bulletin No. 51, page 38, the Chicago Tie & Preserving Co. states that in the tests made for the Bureau at their Chicago plant in a twelve-hour treatment by the "zinc-tannin" process, the absorption by the white oak was only 16 per cent. against 25.5 per cent. by black oak, and in quantity of salts absorbed per cubic foot, the white oak took up less than one-half as much as the black oak. White oak, on account of its density, is classed as a refractory timber to treat, and the fact that it is not treated to any extent by the companies using treated ties, even where white oak is available, would indicate that it is not generally considered profitable at this time. Future conditions of supply and cost without much doubt will modify this view of the case, and if a treating plant is to be installed, it should be made the subject of careful investigation and study before conclusions are reached. The black oak used in the above experiment came from Pennsylvania and was furnished by the Pennsylvania Railroad Co.

Chestnut ties untreated resist decay, and were it not for the fact that they cut badly under the rails they would give as long service as untreated white oak, and even with the use of tie plates, chestnut ties are usually removed from other causes than decay. As the several methods of treatment are for the purpose of preventing decay, and decay is not the defect that limits the life of the chestnut tie, it is generally conceded that it is not profitable to treat chestnut ties under present conditions.

The black oak and red oak ties, however, on account of their porosity, lend themselves readily to treatment, resist the cutting of the rail fairly well, and, with the use of tie plates and treatment, may be made to last fully as long as, if not longer than, a first-class untreated white oak or yellow pine tie. Timber of the black oak and red oak species is more plentiful in Pennsylvania, New Jersey and part of New York than any other variety of inferior woods with the exception of chestnut.

The number of ties of red and black oak, bull pine and other inferior woods that can be obtained annually by a number of the railroads running through the timbered portions of these States and from the forests located along the rivers would indicate pretty conclusively that the supply of available timber in sight for treatment is sufficient to warrant a very careful consideration of this subject by some of the Eastern railroads.

Preparation of Timber for Treatment.—Timber which is to be used, treated or untreated, for any purpose, is the better if thoroughly seasoned. The seasoning of timber both strengthens it and prolongs its life in service. In its green state the walls of the wood cells are more or less plastic, according as the wood is soft or hard, and by the evaporation of the water in the sap and the drying of the starch and mineral salts carried in solution, the wood fiber becomes harder, stiffer and better fitted to resist impact and bending stresses.

The sap, if confined in the wood, as is the case with unseasoned wood partly buried in the ground, soon ferments, producing conditions particularly favorable to the growth of wood fungus and consequent decay. In the case of timber to be treated it is also necessary that the water and sap should be evaporated in order that the wood cells may be open and void to admit of the preserving solution and allow it to pass freely into the timber.

There are three methods of seasoning, all more or less employed in the preparation of timber for treatment:

(1) Exposing the timber to the action of sun and air by piling it loosely so that the air has ready access through the pile to all parts of the timber, but so arranging the top courses as to shed as much rain as possible from the interior of the pile.

(2) Exposing the timber to artificial heat for a time in a kiln, thus accomplishing in a short time what is accomplished in a much longer time by the first method.

(3) By placing the timber in a retort or cylinder and subjecting it to steam under pressure, thus evaporating the water in the sap and forcing the steam into the wood cells. In this latter method it is usually the case to follow this steaming process by a partial vacuum in order to draw out the water from the condensed steam from the cells and leave them open for the reception of the solution.

Of these three methods, the second, or kiln drying process is too expensive to adopt for ties, and, by too rapid seasoning, it checks and warps the timber badly and lessens its power to hold the spikes. The third or steaming process is the one formerly used on the Santa Fe and Southern Pacific Railroads for the preparation of the soft mountain and loblolly pines for treatment and is largely used to-day both North and South.

There is much to be said in favor of this method, especially in the wet, humid climates of the Southern States where some woods will decay before they will thoroughly season in air and where most woods take much longer to dry out and season than in our Northern and Western States. This method is still in use on the Southern Pacific and on the Union Pacific Railroad, and in answer to a letter of inquiry sent out by the Committee on Tie Preservation of the American Railway Engineering and Maintenance of Way Association, Mr. Kruttschnitt, of these roads says:

"We have found it best at all of our works to apply a vacuum before admitting live steam. We think it promotes the seasoning of the timber by removal of the fermentable sap, the retention of which serves to promote decay. We raise the steam pressure to 25 lb., but prefer to specify the temperature above which the timber shall not be heated rather than the steam pressure. We have found with Pacific Coast timbers that they are not injured if the (upper grade of) temperature be limited to 280° Fahr., and the Eastern yellow pines are not injured if the temperature be limited to 250° Fahr."

Mr. Kruttschnitt, however, specifies 90 days' air seasoning before the use of steam, and for that reason does not require as long a period of steam application to prepare the wood for the reception of the solution as would otherwise be necessary. He uses the zinc chloride treatment on the soft loblolly and mountain pines. On the other hand, it has been shown by tests made by the Government involving between 6,000 and 7,000 specimens, that excessive steaming practically destroys the usefulness of the tie, causing it to lose power to resist impact and causing it to become brittle. It has been shown by test that a steam pressure of 50 lb. applied for four hours caused a decrease of 25 per cent. in strength.

In a subsequent report to the U. S. Department of Agriculture by W. Kendrick Hatt, Ph. D., of Purdue University, entitled "Experiments on the Strength of Treated Timber," issued August 7, 1906, after exhaustive experiments on treated and untreated loblolly pine ties, Prof. Hatt reaches the following conclusions:

(1) "A high degree of steaming is injurious to wood. The degree of steaming at which pronounced harm results will depend on the quality of the wood and its degree of seasoning, and upon the pressure or temperature of steam and the duration of its application. For loblolly pine the limit of safety is 30 lb. for four hours or 20 lb. for six hours."

(2) "The presence of zinc chloride will not weaken wood under static loading, although the indications are that the wood becomes brittle under impact."

(3) "The presence of creosote will not weaken wood of itself, since apparently it is present only in the openings of the cells and does not get into the cell walls. Its action therefore can only be to retard the seasoning of the wood."

This series of experiments was confined to loblolly pine so that we can not conclude that they show what the effect of the steaming process would be on the inferior oaks, but we may safely assume that an injurious effect would result in a greater or less degree. It would, therefore, seem that nature's method, first mentioned, of air seasoning is the safest and most effective method of preparing timber for treatment in order to secure the best results in service.

The period of exposure necessary to thoroughly season ties for treatment differs widely with the kind of timber and the climate. It differs also with the season of year, timber drying very slowly in winter and very rapidly in the hot summer months. In this connection, Mr. Faulkner, in charge of the tie and timber department of the Santa Fe, says:

"Take the question of piling ties to start with. We have given some attention to this matter, and for that reason fully realize its importance, but find that for the climate and woods of Eastern Texas, where the rainfall is heavy and at certain seasons of the year the atmosphere very warm and humid, the form most suitable there is not suited to the climate and woods of the Rocky Mountain region. In East Texas our ties are hauled to the right of way, inspected and brought into the Somerville storage yard as quickly as possible after making, and there piled on the 1 x 8 plan so as to give the best opportunity for quickly drying out and for the rain to fall off. We tried the same plan in New Mexico, but found the hot sun and dry air seasoned the outside of the ties so fast that they checked badly, so we made piles 7 x 7 with the outside ones on edge where the shape will permit, just as suggested. In the case of cypress ties, we pile them as solid and close as possible in order to hold the water or sap in the wood. As to the time of drying; this, too, depends somewhat on local conditions. In Arizona a certain lot of ties cut in June lost 33.1 per cent. of their weight in the first thirty days, and in the next ninety the total additional loss in weight was only 1.6 per cent. Ties cut in December were held six months before the loss in weight equaled thirty days in the other case and, until the warm spring days, practically no decrease in weight occurred after the first month.

"If we expect the best results out of treated inferior woods, we must give them a fair show, and this is not done in putting them in the track just as soon as they have probably seventy or more pounds of water in each tie; and when some of this water will squirt out as the spike is driven. What can one expect from a soft pine tie under such conditions, but rail-cutting, loose and damaged spikes and unsatisfactory service? A year ago one of the leading roads in the West noticed their treated ties were corroding spikes. After full investigation I reported that, in my opinion, where the ties were allowed to properly dry out before insertion, the damage from corrosion was scarcely noticeable, but where the contrary was the case, then some corrosion took place; but, even then, nothing like so serious as to give concern. Now that so many roads are using Burnettized or Wellhouse ties, special attention should be called to the necessity of seasoning after treatment, even if more ties are ordered to admit of this, as I believe it would pay good interest on the investment."

At the new Somerville plant of the Santa Fe Mr. Faulkner is using the method of air seasoning, having abandoned the steaming process.

In the climate of the Middle Eastern States it is safe to say that oak will thoroughly season in one summer, and ties cut during the winter should be properly piled and allowed to dry out before being put in the track. This would require a double supply of ties for the first year. For a complete discussion of this subject and best methods of piling ties, see Bulletin No. 41, U. S. Department of Agriculture, entitled "Seasoning of Timber."

Methods and Cost of Treatment.—There are five processes most commonly used for preserving timber, viz.: (*a*) zinc-chloride process, or Burnettizing; (*b*) zinc-tannin process, or Wellhouse; (*c*) creosoting process, or Bethell; (*d*) creosoting (Rueping) process, and (*e*) zinc-creosoting. They may be described as follows:

(*a*) The zinc-chloride process consists of first preparing the timber for treatment by either the steam-vacuum or air-seasoning process, as before described, and then injecting into the open pores or cells of the wood a solution of zinc chloride. The solution is injected under a pressure of from 120 to 145 lb. per square inch, the pressure depending upon the density of the wood under treatment. The solution should also be applied heated from 80° to 100° Fahr., according to Rowe, and 150° Fahr., according to Chanute. The pressure should be maintained until the wood refuses to absorb more. The length of time and the pressure necessary to accomplish best results must be determined by experiment, but when once determined should vary only slightly for the same variety of timber under similar conditions. The strength of the solution used differs according to the weight of dry zinc chloride per cubic foot of timber required by the specifications. The specifications of the Southern Pacific R. R. call for the retention of ¼ lb. of dry salt per cubic foot of timber; the Union Pacific 4/10 lb.; the Atchison, Topeka & Santa Fe, ½ lb., and the Great Northern 1 lb.

For a retention of ½ lb. of salt, the solution, according to Mr. Chanute, should have a strength of 3.7 per cent., and, according to Mr. Rowe, 4 per cent. of zinc chloride. The great objection to this process is that the zinc chloride, being a salt, readily dissolves when exposed to moisture and under ordinary tie conditions, the salt in time leaches out leaving the tie as susceptible to decay as before. The only consideration that recommends this process over the others is its cheapness and possibly the fact that the average physical life of the soft pine ties, used on the Southern and Southwestern roads, is as long by this treatment as the mechanical life without the use of tie plates.

(*b*) The zinc-tannin process resulted from efforts made to discover some process whereby the leaching out of the zinc chloride might be prevented and its efficacy as an antiseptic correspondingly increased. This process consists of first injecting the solution of zinc chloride in the same strength and manner as just described. This solution is then withdrawn from the retort and a 2 per cent. solution of common glue applied for two hours under like pressure and temperature. This process is then followed by the application of a 2 per cent. solution of tannin for two hours in like manner. The process is then complete, and requires about twelve hours.

The tannin (extract of hemlock bark) used in this process is a reddish powder and contains from 15 per cent. to 30 per cent. of tannin acid. It is readily soluble in water at a temperature of 100° Fahr. or over. While the tannin and glue are both soluble in water and the glue in its free state is subject to decay and is a detriment to the wood, yet the tannic acid neutralizes the glue and forms an insoluble compound known as "leatheroid," which fills the ends of the pores and forms a dam or plug which prevents the leaching out of the zinc chloride. This process is extensively used and, although somewhat more expensive and requiring a longer time and a more expensive plant, is much more effective than the zinc-chloride process of which it is a modification. At some plants the solution of glue is mixed with the zinc chloride and injected at the same operation, thus reducing the process to two instead of three operations. This, however, does not give as good results, for the reason that the glue is injected to such a depth that it is not all reached and neutralized by the tannic acid, and so remaining as an element of decay.

(*c*) Creosoting, or the Bethell process, is the most simple and effective, although the most expensive of all the processes. It consists of injecting into the cells of the wood, previously seasoned, creosote or dead oil of coal tar, a by-product from the manufacture of illuminating gas. The oil is injected under a pressure of 100 lb. and at a temperature of from 170° to 180° Fahr. The practice in this country has been to require the retention of 10 lb. of the oil per cubic foot of wood; in England 10 to 12 lb., in Germany 12 lb., and in France, where they obtain a life of 25 to 30 years from beech ties with the use of tie plates and wood screws, they use from 13 to 15 lb. per cubic foot. The large cost of this process lies entirely in the cost of the oil, as the plant and labor of treating costs about the same as the zinc-chloride process before described.

Creosote, or the dead oil of coal tar, is conceded to be the most effective of all antiseptics used in the preservation of timber. It is composed of compounds of carbon and nitrogen (acids) and nitrogenized compounds (bases) and contains all the constituents necessary for an antiseptic. It is practically insoluble and non-volatile.

(*d*) Creosoting (Rueping) process is a modification of the standard or Bethell process of creosoting and is largely being adopted to cheapen the process by withdrawing a portion of the free oil remaining in the cells of the wood after the withdrawal of the creosote appplied under pressure as by the Bethell process. The claim for this process is that by the injection of 10 lb. the physical life of the tie, being twenty years, is greater than the mechanical life without the use of tie plates and screw spikes. As this means of increasing the mechanical life of the ties and stability of the track has not been adopted to any great extent except for ties used on curves and on bridges the extra amount of oil used to prolong the physical life would not be warranted unless means are used to prolong the mechanical life of the tie. The process is, briefly, as follows:

After the charge of ties is placed in the cylinder or retort an air pressure of from 60 to 75 lb. is maintained for an hour, thus compressing the air in the cells of the wood; then, still maintaining this pressure, the hot oil is forced into the retort, the compressed air in the cylinder being allowed to escape through a pop valve in a dome on top set to blow off at the adopted pressure. When the air is excluded and the cylinder filled with the hot oil, this valve is closed and the pressure raised to 180 to 200 lb. per square inch, by forcing oil into the cylinder with a force pump. After this greater pressure has been maintained for the time necessary to thoroughly impregnate the wood, the cylinder is emptied and the air, compressed within the wood cells, expands, forcing out the free oil and leaving the walls of the cells coated with the antiseptic. A slight modification of this process is practiced at the Shirley, Ind., plant of the Columbia Creosoting Co. Instead of first maintaining a pressure in the wood to compress the air in the cells, the cylinder is filled under normal pressure, then a pressure of 180 lb. per square inch is put on until the wood is impregnated, thus compressing the air in the cells at the same operation; then in a vacuum of from 20 to 25 in. the free oil is drawn out leaving about 8 lb. of creosote per cubic foot of wood, which are the specifications the Big Four requires. The Columbia Company has a ten-year contract with that road to treat 600,000 red oak and beech ties per annum, the railroad company furnishing and delivering the ties at the treating plant.

(*e*) The zinc-creosote process, like the zinc-tannin process, was discovered in trying to devise some way to prevent the leaching out of the zinc chloride, and consists of mixing zinc chloride and creosote in such proportions that about 5 lb. of the oil will be injected per tie or ½ lb. per cubic foot with the ½ lb. of zinc chloride per cubic foot of timber. In this process it is necessary to keep the mixture agitated continuously while in the cylinder to prevent it from separating. There is some doubt whether this mixture is uniformly injected; that is, whether the ties at the top and bottom of the cylinder would not receive varying quantities of zinc chloride and creosote. This process has been used with success abroad, however, and the Chicago Tie Preserving Co. is using it successfully at its Paris, Ill., plant at a cost less than that of the Bethell process. In Germany, where this process is used largely and successfully, zinc chloride is first injected and then the creosote by a second operation. This would seem to be by far the better method and possibly accounts for the excellent results from this process in that country where a life of from twelve to eighteen years for pine ties is obtained.

Probable Cost of Treating.—The price of creosote is increasing and the estimate given for cost of treatment is based on a price of 6½ cents per gallon on cars at tide water. At a specific gravity of 1.05, 1 gal. would weigh 8.75 lb. Then as one tie 7 x 9 in. x 8½ ft. would equal 3.72 cu. ft. of wood, the cost per tie for creosote alone would be as follows:

Creosote per cu. ft.	Process.	Cost.
10 lbs.	Bethell	27.56 cents
8 "	Used by Columbia Co.	22.08 "
5 "	Used at Somerville, Tex.	13.78 "
1 "		2.756 "

In Table 1, which shows the probable cost of treatment per tie 7 x 9 in. by 8½ ft., the average cost to the Atchison, Topeka & Santa Fe has been used as is given in Rowe's handbook entitled "Preservation of Timber," dated 1904, page 177, correcting the cost of different items for the size of tie noted, 7 x 9 in. x 8½ ft. The size of tie used on the Santa Fe Railroad is 6 x 8 in. x 8 ft. and contains 2.67 cu. ft. of timber, while a 7 x 9 in. x 8½ ft. tie contains 3.72 cu. ft. or 1.4 times as much.

TABLE 1. COST IN CENTS OF TREATING A 7X9-IN. BY 8½-FT. TIE.

Process.	Chemicals.	Labor.	Fuel.	Supplies.	Int. and Sink. Fd.	Total cost.
Zinc-chloride (Burnett)....	7.56	5.54	0.81	0.34	2.00	16¼
Zinc-tannin (Wellhouse)...	9.65	5.03	1.02	0.30	2.00	18
Creosote (Rueping*) *a*....	13.78	5.54	0.81	0.34	2.00	24.57
Creosote (Rueping*) *b*....	22.08	5.54	0.81	0.34	2.00	30.77
Creosote (Bethell) *c*....	27.56	5.54	0.81	0.34	2.00	36¼
Zinc-creosote *d*....	11.56	5.03	1.02	0.30	2.00	19.91

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* The Rueping process is patented and 1½ cents per ties for royalty must be added to the cost of treatment given in the Table. *a*, As conducted at the Somerville plant, using 5 lb. of creosote per cubic foot of wood. *b*, As conducted by the Columbia Creosoting Co., using 8 lb. of creosote per cubic foot. *c*, Standard process, using 10 lb. of creosote per cubic foot. *d*, Using 5 lb. of creosote oil per tie.

The column "Interest and Sinking Fund" is obtained by taking the assumed first cost of the plant at $100,000 with interest at 4 per cent. and sinking fund to restore plant at the end of twenty years and upon the basis of treating an average of 500,000 ties per year. That the figures for cost of treatment are on the safe side is shown by the fact that the Columbia Creosoting Co. has contracted to furnish 600,000 ties per year for ten years to the Big Four Railroad at practically the same figure as given in the table for cost of treatment by the Rueping process.

Based on the information contained in the pamphlets and published articles examined, the life shown in Table 4 for red and black oak ties treated by the different processes as given in Tables 2 and 3, ought to be realized with traffic conditions as have existed heretofore.

TABLE 2. PROBABLE LIFE OF RED AND BLACK OAK TIES, TREATED BY METHODS GIVEN IN TABLE 1.

Process.	Without Tie Plates, Years.	With Tie Plates and Screw Spikes, Years.
Zinc-chloride	10 to 12	12 to 14
Zinc-tannin	11 to 14	14 to 18
Creosote (Rueping) *a*.......	12 to 15	16 to 18
Creosote (Rueping) *b*.......	14 to 16	18 to 20
Creosote (Bethell)..........	15 to 18	20 to 25
Zinc-creosote..............	12 to 15	14 to 18

TABLE 3. INITIAL COST OF UNTREATED AND TREATED TIES, CONFORMING WITH ITEMS IN TABLE 1.

Kind of Oak.	White.	Red and Black.
Untreated	70 cents	45 cents
Zinc-chloride	....	61¼ "
Zinc-tannin	....	63 "
Creosote (Rueping) *a*........	....	71 "
Creosote (Rueping) *b*........	....	77¼ "
Creosote (Bethell)	....	81¼ "
Zinc-creosote	....	65 "

The figures for the Rueping treatment include royalties.

Then using the "Amortization Tables," shown in the book issued by the Norfolk Creosoting Co., entitled "Creosoted Timber; Its Preparation and Uses," page 90, we have, using 4 per cent. interest, the comparative yearly charge for untreated white oak and treated red oak. In the second column of figures in Table 4 is shown the annual charge of labor of renewal, taken from second table on the same page, by using a labor cost of 15 cents for renewing each tie at the end of its term of life in service. The sum of these two columns of figures gives the total yearly cost of white oak ties untreated compared with that of red or black oak treated by the several processes not using tie plates or screw spikes in either case, with traffic conditions as have existed heretofore.

TABLE 4. ANNUAL CHARGE FOR FIRST-CLASS UNTREATED WHITE OAK TIES AND TREATED RED AND BLACK OAK.

	Life Years.	Tie and Treating, Cent.	Labor in Renewal, Cent.	Total Annual Charge, Cent.
White oak untreated...	10	0.0860	0.0125	0.0985
Red and black oak:—				
Zinc-chloride treatment	10	0.0753	0.0125	0.0878
Zinc-tannin "	11	0.0718	0.0110	0.0828
Creosote (Rueping) *a*	14	0.0667	0.0091	0.0758
Creosote (Rueping) *b*	15	0.0695	0.0075	0.0770
Creosote (Bethell) ..	16	0.0699	0.0068	0.0767
Zinc-creosote treatment	13	0.0650	0.0090	0.0740

This table is prepared with the assumption that interest is at 4 per cent., white oak ties cost 70 cents each, red and black oak ties cost 45 cents each, and the treatment conforms with that in Table 1.

This table indicates a slightly more favorable showing for the zinc-creosote process than the Rueping process, but in preparing the statement of cost, a royalty of 1½ cents per tie has been added for the Rueping process, but no royalty has been added for the zinc-creosote process.

In obtaining the values shown in Table 4, much depends on the actual average life of ties, which is a somewhat uncertain quantity, but the values given seem conservative for ties laid in stone ballast and used without tie plates. If the screw spikes and large tie plates used abroad were adopted there is no doubt but that the Bethell or standard process would show the lowest annual charge as we would expect to realize a life of eighteen or more years by that method. With present methods using what Mr. Chanute terms "the barbaric spike" the adoption of the Rueping process is to be recommended as the most reliable at the smallest cost, which statement applies to the cost of the plant as well as treatment. This is the system which has been adopted by the Atchison, Topeka & Santa Fe Co. after considerable experiment. It is the system which most nearly equalizes the mechanical and chemical life of the tie at a reasonable expense. The cost of treating the inferior oaks by this method could likely be reduced to 25 cents per tie to a company advantageously located from a fuel and transportation standpoint. This table would show an annual profit by the Rueping system of $6.81 per mile based on 300 ties for renewal per mile per annum.

Plant for Treating.—In building a plant it would be advisable to provide for a greater capacity than is needed to treat the average number of track ties replaced annually, as by having this larger plant it could be closed down for repairs or for other reasons for a time each year; and at such a plant fence posts, bridge ties, Southern yellow pine track ties and other materials such as dock timbers could also be treated.

A suitable plant with capacity for treating 800,000 ties per annum, so far as equipment for treating is concerned, would consist of two cylinders 6 ft. 2 in. in diameter by 132 ft. long, together with the necessary pressure cylinders, piping, pumps, boilers, measuring and storage tanks, etc., and would cost ready to install close to $50,000. The buildings would comprise in general: A main building 60 x 160 ft., with a partition lengthwise dividing it into a treating cylinder room and machinery room with a boiler room about 40 x 50 ft., either as a separate building or as an addition to the main building. The entire plant together with standard gauge and narrow gauge tracks, yard room for piling ties, complete ready for operation should be built for approximately $100,000.

An article describing a similar, though larger, plant than above, installed by the Atchison, Topeka & Santa Fe R. R. Co., at Somerville, Tex., will be found in a booklet prepared by the Allis-Chalmers Co., written up by G. B. Shipley and entitled "The Santa Fe's Modern Timber Treating Plant at Somerville, Tex." In the "Railroad Gazette,' of March 16, 1906, an article on the plant of the Columbia Creosote Co. at Shirley, Ind., will be found. Both of these plants use the Rueping system, but under different specifications as to the amount of oil to remain in the tie after treatment and both treat air-seasoned ties without steaming.

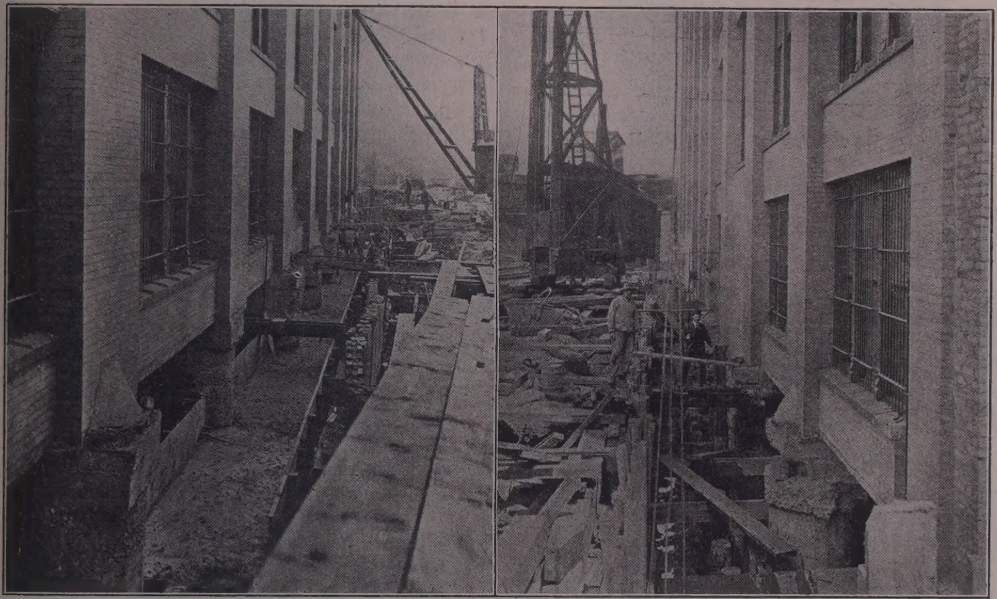
Machinery could be installed at the treating plant for adzing the ties at each end to fit large tie plates like those used abroad and bored for the screw spikes at one operation before treating, and experience in France has shown that by the use of these devices the length of life of a tie may be extended to twenty-five years or more under traffic conditions as have existed in France. The type of fastening in connection with the question of treatment should receive very careful consideration in order to realize the proper and full value from treatment.

The volume of traffic and weight of equipment of our railroads have increased rapidly in the last eight or ten years and on some of the Eastern trunk lines during the past seven years the average increased weight per engine used has been 50 per cent., or at an average rate of 7.1 per cent. per annum increase in engine weight. These changing conditions have an important bearing, particularly on the mechanical life of the tie and the track fastenings.

Tunneling with a Channeler was carried on by the Kenefick-Hammond Co. in constructing a tunnel on the White River division of the St. Louis & San Francisco Ry. The upper portion of the tunnel was in a soft gumbo clay, which caved easily and had to be supported by heavy timbering. The lower 6 to 8 ft. of the tunnel was in solid rock. The contractors were afraid to blast the rock bench in the ordinary way lest the shock of doing this should shake the timbering of the roof and cause the latter to cave. They accordingly set up a Sullivan track channeler close to the side of the roof and cut down with it into the rock. The channeler left a shoulder at the surface of the rock on which the supports of the roof rested. It was generally necessary to make two cuts from 3 to 4 ft. deep, but on one occasion a single cut was carried down to a depth of 8½ ft. After the cuts had been made on both sides in this way the rock between them was drilled and blasted in the usual manner. The entire work executed in this way was 400 ft. long. About one-quarter of it was through tough flint and the remainder through limestone. The channeling machine cut 24 lin. ft. 8½ ft. deep in the flint during the first five days it was at work.

Difficult Underpinning and Dock Work in Chicago.

The increase in the width of the Chicago River and of the South Branch of that stream to a minimum of 200 ft., which is necessitated as a part of the improvements carried on by the Sanitary District of Chicago in connection with the opening of the Chicago Drainage Canal, has already involved a large amount of difficult and expensive construction work. The widening of a narrow place in the South Branch of the river at Van Buren St., ¾ mile from the junction of that branch with the main river and 1¾ mile from Lake Michigan, required some particularly complicated dock and building underpinning work. The river was originally 154 ft. wide at the Van Buren St. crossing and in this vicinity has a practically continuous row of seven, eight and nine-story buildings abutting against the east dock line, with a badly congested railway freight and passenger terminal yard extending up to the west dock line. The widening of the channel to 200 ft. at this point required the removal of a triangular-shaped section, 4 ft. wide at one end, 200 ft. long and 46 ft. wide at the other end, from a large eight-story brick building on the east bank. The uncovered portion of the east bank was then dredged to the standard depth of a minimum of 26 ft., a concrete dock wall having been constructed meanwhile along the new shore line.



Two Views along New Shore Line during Construction of Dock Wall.

The building from which the section had to be removed is a heavy brick structure with a steel frame, the walls being partially self-supporting and are carried partially by the steel frame. The footings on which the building stands are of the spread, or floating type, which was so commonly employed until recently in the construction of buildings on the heavy plastic blue clay which underlies the central business portion of Chicago. As many disastrous results have come from opening excavations in the vicinity of buildings on these spread footings, two rows of heavy circular concrete footings carried down to rock, which lies about 100 ft. below the surface at the site, were built under what was to be the new side of the building along the widened channel. These footings were also provided to carry and to anchor in place the new concrete dock. The removal of the triangular-shaped section of the building was commenced after these footings were in place, the brick walls being taken down gradually from the top and a new face wall built for the building as the work progressed. The dock wall was built under the new face wall before the dredging was started.

Nineteen of the circular concrete footings extending down to rock were built. Ten of these footings are in a row under the new outer wall of the building; the other nine are in a second row, 16 to 21 ft. back under the building from the first row. The footings are 4 and 5 ft. in diameter at the top and were built in circular wells sheeted with 3x6-in. lagging in 3-ft. and 5-ft. lengths. They carry directly the outer wall of the building, the loads on the inner partition walls and the loads on the columns of the steel frame. As they replaced the original spread foundations, the loads on the latter had to be shored up while the wells for them were being sunk and until these wells were filled with concrete. Where the wells came under a partition wall this shoring was not specially difficult, but where a separate column of the steel frame had to be supported the work was more hazardous.

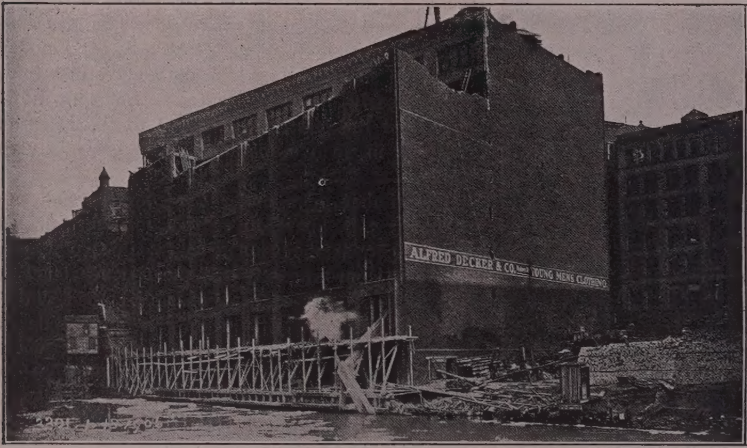
The concrete dock wall along the face of the building does not have a gravity section such as is usually adopted for retaining walls built under similar conditions, but is a heavy concrete cap carried by the outer row of circular concrete footings and by a row of timber piles and sheeting. Two cross-sections of this dock wall, one through a circular concrete building footing and one between two of these footings, are shown in an accompanying illustration. From these cross-sections it may be seen that the center of gravity of the wall section is entirely outside the supporting concrete footings. The row of wooden piles and sheeting on which the wall is also built comes nearly under the center of the wall, however, and the latter is anchored to the concrete footings in such a manner as to make it very stable.

The timber piles under the concrete wall are spaced 3.5 ft. apart on centers and were driven to hard clay at about 40 ft. below Chicago datum, which is approximately the mean river level at this point. A row of 3x12-in. triple-lapped Wakefield sheeting was driven on the shore side of these piles and are attached to two waling pieces on the latter. The piles were cut off 18 in. below datum and the sheeting 3.5 ft. below that level, so that both will always be wet. The heads of the piles and sheeting were also well embedded in the lower part of the wall as shown in the section.

The wall is reinforced longitudinally for its entire length, along its front face and along part of the rear face, with ¾-in. Johnson corrugated bars. Five horizontal layers of ¾-in. bars are also placed transversely in the wall. This reinforcement is provided to tie the wall together and to overcome any heavy strains that may be caused by unequal settlement. At each of the circular concrete footings five ¾-in. bars are bent around the latter and have both ends extending nearly to front face of the walls. These bars are inclined downward from the back of the footing to the front of the wall, in order that they may come into play and exert an upward pull on the wall in case the latter should settle the slightest amount. A concrete shoulder built on each of the footings where the bars pass around the latter encloses and protects the bars.

The tops of the outer row of caissons are anchored back to the tops of those in the second row in order to provide additional stability for the dock wall and to insure against the latter being pushed out of line. The rows of piling and sheeting under the wall are expected to overcome any tendency of the blue clay under the building to flow into the river. This clay has the consistency of stiff dough, however, and exerts a very heavy pressure against walls or sheeting placed to confine it, so the anchorages to the second row of footings were provided. The type of anchor-age adopted to tie the footings in the two rows together depended on the manner in which the footings in the second row are loaded. Where these footings come under a partition wall in the building, that wall is carried between the pairs of footings in the two rows by two or four 24-in. I-beams, depending on the amount of the load. These beams are embedded in the tops of the footings and are each anchored at the dock wall end by a 1⅝-in. rod attached to the beam by a clevis and bolted to two horizontal channels embedded in the concrete of the wall. Where the footings of the rear row carry a column only the corresponding footings of the outer row and the dock are anchored to them by two pairs of 1¼-in. rods. These rods are bolted at one end to two horizontal channels embedded near the face of the dock wall. Their other ends are bolted between a pair of 15-in., 30-lb. channels on the rear side of the rear footing of the pair. In five of the nine pairs of footings in the two rows the footing in the rear row is anchored by a pair of 1⅜-in. rods to channels in a 2x4x9-ft. reinforced-concrete block buried farther back under the building. The footing at one end of the outer row is not paired with one in the rear row, so it is also anchored back to channels in a buried block of concrete in a similar manner.

The construction of the dock was a comparatively simple matter, although carried on in limited space and under complicated conditions.

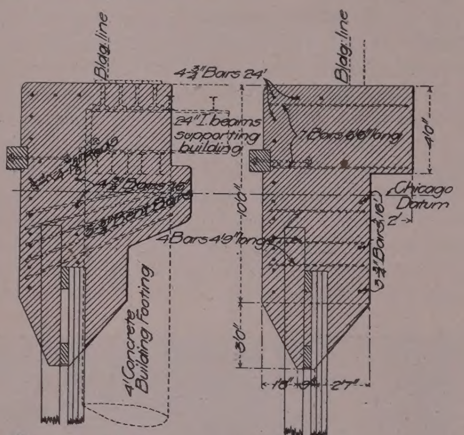


Part of Building Being Razed.

New Building Wall Completed.

After the portion of the building to be removed had been razed, from one to three rows of temporary 3x12-in. sheeting were driven on the outer side of the site of the rows of permanent sheet piling and about 6 ft. from the building line. A trench of roughly the same cross-section as the dock wall was then opened up in the short sections along the building side of the row of sheeting. The row of permanent dock piles and the row of permanent triple-lapped sheeting were driven in the bottom of this excavation with a land pile driver having 55-ft. leads and a 2,500-lb. drop hammer. The driver was operated on rollers on what was formerly the basement floor of the part of the building that had been removed. When these piles had all been placed the plastic clay had swollen up in the bottom of the trench; this surplus was removed and the forms for the concrete dock wall were erected after the trench had been completed.

The concrete was made in a mixer on a scow moored along the work. This mixer discharged into ¾-yd. buckets which were handled from the scow to the forms by a turntable derrick mounted on a car that traveled the length of the work on a track laid on the ground between the new building line and the old dock line. The wall forms were all braced against the sheeting and no significant trouble was encountered in placing the concrete. The wall was built in short sections to avoid having too much of the trench open at a time. The strip of land between the wall trench and the old dock line being quite narrow at one end considerable water was encountered in excavating the last section of the trench and in placing the last of the concrete. A 7-ft. sewer in Van Buren St. close to this end of the work had to be maintained without damage, so a cofferdam was built in the river around the end of the work before the excavation was started. A 3-ft. 9-in. sewer from the building also had to be maintained during the work.



Section at Footings Intermediate Section

Sections of Dock Wall.

The contract price for the type of dock wall built was $67 per linear foot, complete; proposals were invited for the construction of a wall with a gravity section and the lowest resulting bid was $190 per linear foot. Furthermore, the construction of a gravity section wall would have necessitated an excavation much deeper than the one required by the adopted plan, and such an excavation could not have been made so close to the river in the extremely plastic clay, without great hazard.

The tenants of the building occupied the latter during the alterations, a temporary partition being built in the building 6 ft. inside the line of the new wall. As fast as the portion of the building to be removed was taken down the new wall was built, beginning at the top floor.

The widening of the Chicago River is being done by the Sanitary District of Chicago under the supervision of Mr. Isham Randolph, chief engineer. Mr. George M. Wisner, assistant chief engineer for the district, designed and directed the construction of the dock and underpinning work. The Great Lakes Dredge & Dock Co., of Chicago, executed the construction, Capt. Wm. Murphy being immediately in charge.

Rail Corrugation is attributed by the engineer of the Boston Elevated Ry. mainly to the skidding of inside wheels on curves.

Professional Ideals of the Twentieth Century.

Address of President Hadley of Yale University at the dedication of the Engineering Societies Building on April 16.

A building like this is the best monument of what the twentieth century has accomplished.

The really important part of the history of a nation is the development of its ideals and standards. The specific things that it does are important not so much for their own sake, but for the sake of the evidence they give as to the trend of a nation's thought. It is not the magnitude of the individual battles which makes a war worth reading about. It is the ideas under which the war is conducted and the constitutional principles for which it is fought. It is not the census figures which decide whether a nation is great or small. It is the industrial methods and educational ideals which these census figures indicate. And in like manner it is not the buildings and machines and railroads and mines which constitute the important part of the history of the engineering profession. A book might give a good description of a thousand of these great engineering works, and yet fail of being in any sense a true history of engineering progress. The thought of the successive builders and the influence of that thought upon the conduct and ideals of other men are the things that we really care about. The story of the concrete achievements that have dazzled the eye of the world is but the unimportant and superficial part of the history. The real thing for which we care, the thing that helps us to understand the past and inspires us with hope for the future, is the story of the men who did the things—their struggles and their discoveries, their trials and their successes.

The men who did more than anything else to make the nineteenth century different from the other centuries that went before it were its engineers. Down to the close of the eighteenth century the thinking of the country was dominated by its theologians, its jurists and its physicians. These were by tradition the learned professions; the callings in which profound thought was needed; the occupations where successful men were venerated for their brains. It was reserved for the nineteenth century to recognize the dominance of abstract thought in a new field—the field of constructive effort—and to revere the trained scientific expert for what he had done in these lines. Engineering, which a hundred years ago was but a subordinate branch of the military art, has become in the years which have since elapsed a dominant factor in the intelligent practice of every art where power is to be applied with economy and intelligence.

A building like this is, therefore, the symbol of all that is most distinctive in the thought of the entury that has gone by. A hundred years ago e might have had a building in honor of theo- gians or of lawyers or of physicians; but one at symbolized the achievements of the engineer as beyond man's dreams, because the world at rge had neither felt the need of his work nor reamed how soon it should be seeking his lead- rship.

I have spoken of this building as a monument, ut that is after all not the proper word. A mon- ment implies that a man is dead, or at any rate at he has so nearly reached the limit of his rowth that he might just as well be dead. ooked at in this way, the engineering profes- on wants no monument. It has not yet reached e limit of its growth. It has not come to the me when a complacent survey of the past will ke the place of toilsome planning for the future. ot a headstone do we want, but a milestone— point at which our measurement of what has een already done serves as an inspiration for the urney yet to be traversed. We may take this pportunity for a brief review of what has been one in engineering and other allied professions; ut the engineer who is worthy of his calling will alue that review most highly if it is made a eans of calling his attention to that which yet emains to be done.

A hundred years ago there was a sharp sep- ration between scientific theory and commercial ractice. There was not a great deal of science nyway, outside of mathematics and astronomy, nd what there was was underrated by men of ffairs. In those days when a man said he was ractical it meant that he was not theoretical; at he didn't know science, and didn't want to now it, and didn't want to have any man around at did know it. The men of that day trusted two guides: inherited prejudice and individual xperience. The more enlightened among them sed experience to correct prejudice; the rank nd file of them used experience to reinforce rejudice, and that was about all the difference. he value of generalizations, except in religion nd in statecraft, and in some few branches of edicine, was not recognized by anybody.

The great element of progress in the nineteenth entury has been the recognition on the part of ankind in general of the value of scientific gen- ralizations in every department of human con- uct. Our science has become sounder, our un- erstanding of its applications clearer; and the ublic has recognized that scientific conduct of business means the substitution of universal xperience, learned with difficulty and applied with il, for the narrower range of individual ex- erience which was at the disposal of the so-called ractical men of fifty or a hundred years ago. Of is change the engineer is the representative and e leader. He it is who makes physical science its various lines applicable to the complex roblems of construction and development. He is who has paved the way for the recognition f the technologist and the expert in every line f human industry. He it is who has shown how athematics, instead of being an abstract disci- line, remote from everyday human affairs, may ecome the means of applying truths for a long me remote and undiscovered to the everyday ffairs of the world in which we live. Not the uildings that you have built, gentlemen; not the ilroads that you have planned; not the machines at you have invented, represent your greatest chievement. Yours is the proud boast of having one brief century established science as the rbiter of the material affairs of mankind, and f having enforced her worship upon a world nce reluctant, but now gloriously admiring.

What, then, you will ask; is there anything hich remains to be done comparable in import- nce to this? Yes, there is. An equally large art—perhaps in one sense a much larger part— f your professional duty yet remains to be accomplished. It is not enough to have technical training. It is not enough to know the special sciences on which the practice of a profession is based. A man ought to have clear conceptions of the public service which his profession can render and the public duty which its members owe. Thus, and thus only, can the engineer, the lawyer, the physician, or a member of any other learned profession, rise to the full dignity of his calling.

For there are two quite distinct qualities which must be combined in order to secure the best professional service; two quite distinct tests which work must meet in order to be pronounced first-class. One of these is the technical standard; the other, for want of a better word, may be called the ethical standard. The man who wishes to build a good railroad must not only lay it out according to the rules of the surveyor's art, with proper curves and grades and bridges which will not fall, but he must also have some intelligent regard to the needs of the population, the safety of travel, and the many other factors which determine whether a railroad shall be a work of public use or a source of industrial bickering and financial disaster. This combination of public and private demands is not peculiar to engineering. It can be illustrated in every other profession of importance. It is not enough for the lawyer to give advice which shall be technically sound and which shall enable his clients to keep out of jail. He must learn to take a large view of the law as a means of public service instead of private gain. It is not enough for the physician to know how to cure specific diseases. He must know how to care for the larger problems of public health, and to use the resources of the community in a way to meet as fully as possible its sanitary needs.

This larger view of professional obligations is not so fully recognized as it should be. We have in the nineteenth century made so much progress in the technical training of doctors and lawyers and engineers that we sometimes forget that there is need of anything more than technical training. We have let the old idea of public leadership, which was prominent in the minds of the great professional men of past centuries, give place to another and narrower ideal which is fully satisfied when a man has made himself a technical expert. Many a man of real eminence in his calling deliberately rejects the wider conception of professional duty which I have here indicated. Perhaps he recognizes the claims of public service, perhaps he does not; but in any event he believes that these claims rest upon him as a man rather than as an engineer or a lawyer. In his professional capacity he says he is hired not to tell what the law ought to be, but what it is; not to advise how a railroad can do the most public service, but how certain men with certain ideas of their own can best use the differential calculus to get those ideas carried out. This is perhaps the prevalent view of professional ethics to-day. I believe that it is a wrong view, which must menace not only the influence and standing of the professions themselves, but the general interests of the republic.

In the first place, a man who believes that he is hired to carry out another man's ideas can never claim a position of actual leadership. He remains a paid servant—highly paid, doubtless, because he is possessed of a kind of skill which is very unusual, but nevertheless a servant, bound to carry out the wishes of his master. A group of professional men which regards this as a proper view thereby forfeits the claim to stand in the first rank socially and politically, and voluntarily accepts a position of the second rank. I do not believe that the engineers of America want to do this. It has been said that engineering is the handmaiden of commerce; but I do not believe that the men who have planned and dedicated this building will be satisfied with any handmaidenly conceptions of what their successors ought to do. If for a moment, in our zeal for new technical developments, we have let our responsibilities as public servants fall out of our hands, I feel sure that we shall be ready to take them up again as soon as our eyes are opened to the real situation.

For mere technical achievement is not the thing that endures. Among the peoples of the ancient world, I suppose that there were no engineers equal to those of Egypt. Considering the means at their command, the things that they did were absolutely extraordinary. They did some things which, even with the means at our command, we can hardly duplicate. But they used their abilities in the service of a dominant priestly caste; and therefore, while their work fills us with admiration, it does not appeal to us as does the work of the Roman engineers a few centuries later, who built roads and aqueducts and bridges, and thus took the lead side by side with the Roman lawyers in establishing the basis of modern civilization. The roads and bridges of Rome, simple and straightforward as they are, constitute a more enduring monument to the Roman engineers than all the obelisks and pyramids that were ever erected.

For their own sake, then, and for the sake of the enduring quality of their work, we can appeal to the engineers and lawyers and physicians to see that it is adapted to public ends. We can reinforce this appeal by a yet stronger one on behalf of the American commonwealth as a whole, for the development of technical ideals and standards in our various professions during the last few centuries, to the neglect or exclusion of ethical ones, is constituting a very serious public danger.

A commonwealth like that of the United States is necessarily governed by public opinion. Courts may formulate this opinion. Legislatures may pass rules to give effect to it. Police may enforce its demands against the recalcitrant. But the governing power rests in the intelligent public opinion itself. When that opinion ceases to be intelligent and powerful, freedom becomes a mere name. Now a serviceable public opinion of this kind can only be formed when intelligent people, technically trained for different lines of life, seriously try to find out how their work can be made to meet the public needs. They are the only ones who can do this well. If it is done by anybody else it will be done badly. If the lawyers as a class try to keep the law in line with the demands of intelligent public opinion, we can get good law. But if lawyers are content to see the law perverted to private ends, and judges take refuge in technical construction of precedents, without full regard to the needs of the existing situation, legislatures will step in to create a chaos of conflicting laws which are worse than no law at all. In like manner, if our engineers get their own minds clear, and get the public mind clear, as to the political economy of the properties entrusted to their charge and the ethics of their management, they can forestall those conflicts which now threaten to break out at every moment. But if the members of a profession whose advice is necessary in order to a clear understanding and wise settlement of these problems retire from the field of action, the matter will be settled by those whose interests are more selfish and less far-sighted. There are three professions to-day which do not regard themselves as servants, but as masters—the financier, the journalist and the politician. If the engineer and the lawyer accept positions as servants, simply putting their technical knowledge at the disposal of merchant, journalist or politician, who will pay the highest price for it, it is not simply a confession of inferiority; it is a dereliction of public duty.

Do you say that it is impossible for a single man or group of men to remedy these evils? Look at the career of Albert Finck, who in 1874, when he was an engineer on the Louisville & Nashville R. R., made a study of the cost of transportation which has been at the basis of all the intelligent management of the traffic departments of railroads from that time to this. Of course Albert Finck was a rare man. He could do things that some of the rest of us cannot. But I verily believe that if our professions could awake to the necessity of broad ideals like those of Finck, the greatest dangers which threaten the American commonwealth would be fairly met, and the men who met them would be given the positions of power and trust which they had proved themselves worthy to hold. Nobody is satisfied to-day with the struggle between individualism and socialism, between financier and politician, between Wall Street and Washington. The men who are engaged in this conflict are for the most part heartily sick of it. Let a man or group of men arise who add to their technical knowledge a readiness to use that knowledge in the public service, and people will be ready to put them in charge of affairs and follow where they lead. We have outgrown the day when a little common sense was sufficient for managing the affairs of the nation. They are become too complex; and this complexity gives the engineer, if he will add to his training in mathematics a training in ethics and political economy and the fundamental principles of the law, an opportunity such as never before existed to claim and receive the position which rightfully belongs to him.

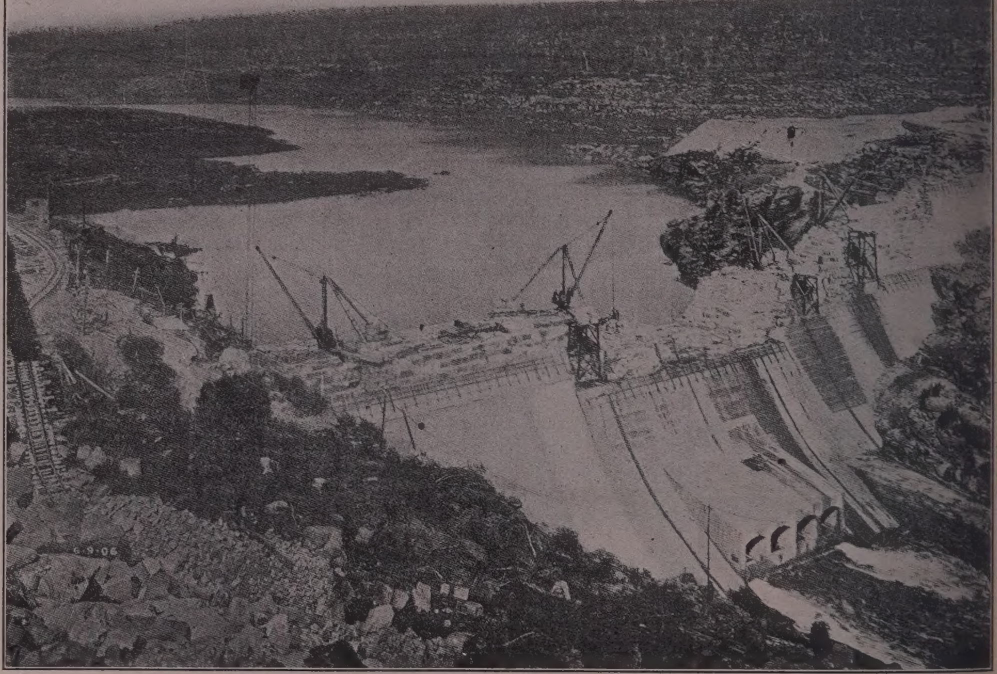
There arises now and then among our engineers a man with this quality of looking into the future—call it genius, call it insight, call it imagination. One of your own members said in a memorable speech that the thing that distinguishes a man of the first rank in his profession from a man of the second rank is the possession of this quality of imagination. Unfortunately it is rare. We cannot all of us have it. But we can have more of it than we now have, if we will modify our training and widen our standards of professional success. Excellent as is the course in our technical schools, it does tend to have a narrowing effect instead of a broadening one. The ideals of our engineering societies are high, but they are not always as broad as they might be. The widening of the course in the schools and greater readiness in our associations to recognize services which we now call non-professional will, I am convinced, do more for the engineers and more for the community than would be represented by ten years' progress in mining or machinery and the various developments of applied science.

We celebrate to-day, and we are justified in celebrating, the recognition of science as a necessary guide in the conduct of the material affairs of each man's business. Half a century hence, when our descendants shall meet in this building or some greater building, I am confident that they will celebrate a yet greater thing—the recognition of the right of men of science to take the lead in enlightening the thought of the people on public affairs and the responsibility of filling the highest positions in the service of the commonwealth.

Improved Boiler Operation is claimed for plants using the Temperley-Cockburn apparatus. It requires the insertion in each tube of a water-tube boiler of a small pipe, perforated on its upper surface and placed near the top inner surface of the water tube, in order that the steam may be drawn off at once as it is formed in each tube, thus preventing the escape of a frothy mixture of steam and water. Combined with this is an arrangement for the progressive heating of the feed in the water tubes farthest from the fire, and an arrangement of air jets at the front of the fire. The London Electric Supply Corporation is testing the system.

The Cataract Dam.

The Cataract dam for the additional water supply of Sydney, New South Wales, will be completed in a few months, in all probability, and attention is accordingly drawn again to this rather unusual structure, a full account of which was published in The Engineering Record of Nov. 5, 1904. Since that article appeared a few changes have been made and the plan of construction has been altered from day labor to contract. The accompanying cut, taken from the report of the Department of Public Works of New South Wales for 1906, shows the appearance of the structure last fall. The water supply of the city, until storage was provided by the partly completed Cataract dam, was drawn from a reservoir containing about 9,000,000,000 imp. gal. only partly available for use. The new dam is constructed within the watershed of this reservoir and will furnish an additional storage capacity of about 21,000,000,000 imp. gal. The deficiency in the water supply of the city in the past has not been due to any lack of rainfall on the catchment basin of the rivers from which the water is drawn, but to insufficient storage capacity.



The Condition of the Cataract Dam Last Fall.

The general dimensions of the dam are 811 ft. length, 154 ft. height above the river bed, 40 ft. depth below the river bed, 16 ft. top width, 158 ft. bottom width and 147 ft. maximum depth of stored water. The area covered by the reservoir when full is 2,145 acres. The total cost of the work is expected to be about $1,665,000. The dam will close a rock gorge with steep sides, the rock being a hard sandstone found near the surface all the way across the site. It was originally expected, as stated in the previous article on the structure published in this journal, that the excavation would not have to go lower than 20 ft. below the original surface of the ground, but this expectation was unfortunately based on incomplete information regarding the underlying strata.

The heart of the dam has been constructed of fairly rectangular blocks of sandstone taken from the site. The size of the blocks was limited only by the capacity of the cableways used in handling them, and ran up to four or five tons. The stones are laid in Portland cement mortar, and the joints are of concrete, the ratio of stone to mortar and concrete being about 65:35. The sandstone does not weather very well, and accordingly in the design of the dam the upstream face was provided with a protection of concrete blocks and the downstream face with a surfacing of concrete approximately 6 ft. thick. This concrete is made of a crushed bluestone or basalt obtained about 6 miles from the dam. The concrete blocks are about 5 ft. long, 2½ ft. thick and 2 ft. high, and are bedded and jointed in a special cement mortar, and backed by about 3 ft. of bluestone concrete. A great deal of care was spent in the manufacture and laying of these blocks and their backing, because on this part of the structure alone is reliance placed to secure imperviousness. The body of the dam is provided with drains which are carried out to the downstream face, this structure being probably the second large dam in the world to be drained so thoroughly, the first of its kind being the large dam of the Vyrnwy supply of the Liverpool Water Works.

A by-pass to discharge surplus flood water, with a weir 720 ft. long, is provided in the rock around one end of the dam. The top of the weir is about 150 ft. above the original river bed, and the water flowing over it joins the river about one-eighth of a mile below the dam. The top of the dam is 7 ft. higher than the top of the weir. Two 48-in. pipes with valves communicating with outlet wells and sluice valves in the upstream face of the work form the permanent outlet. Two additional 48-in. pipes, making four in all, have been provided to pass the river flow during construction. The valve house is on the downstream side of the dam and is roofed with reinforced concrete, as shown in the accompanying illustration, to provide against damage by water passing over the works during construction. The valve chambers are reached through a passageway from one end of the dam, and within the latter.

The contract under which the work has been conducted since May, 1905, provided that the valves should be left open until the lowest portion of the wall reached a level approximately 80 ft. above the river bed. This provision is interesting on account of an unusual flood which overtopped the dam during construction. An ex-

edingly dry period of 15 months duration re-
ted in the depletion of the city supply; in fact,
e flow of the river during this period was so
all that a single 48-in. pipe was ample to carry
off. An arrangement was accordingly made
th the contractors that the valve should be
sed and water impounded on Aug. 30 of last
ar. Two days before that date work was being
ncentrated upon the lowest portion of the wall,
en 76 ft. above the river bed, the gap being
out 65 ft. in width. On Aug. 29 there were
me showers and on Aug. 30 at 5 o'clock in the
ernoon the valves were closed. At 6 o'clock
the same day, after 15 months of dry weather,
heavy rain amounting to 10 in. fell in the catch-
ent area, and 12 hours later water was flowing
er the dam to a depth of 16 ft. in the gap, and
e lake above the dam held approximately 2,000,-
0,000 gal. The engineers opened one of the
-in. valves to reduce the discharge, but it was
t considered advisable to open the other three
account of the vibration likely to result from
e high velocity, as the fixing of the valves in
ce was incomplete. Rain ceased on Aug. 31
d on Sept. 3 the discharge from the open valves
d over the wall had reduced the level in the
e to that of the top of the dam, 76 ft., when
e valve was partially closed and work resumed.
amination showed that no damage was done
the structure, though one or two blocks of
ndstone which had not been set were carried
om the top of the dam and struck the roof of
e valve house in falling.

Construction was begun in the field during
ctober, 1902, by commencing the clearing of the
e of the reservoir, which was heavily wooded.
he whole basin was first cross-sectioned from
e top water level to the other, to ascertain the
obable capacity; the top contour was leveled
ong its length of 50 miles and the clearing block
en subdivided into areas of one to five acres.
he total area cleared is about 2,400 acres and
e work cost about $60,000. A force of about
0 men was employed on this work.

The dam is about 50 miles from Sydney and 15
les from the nearest railroad station. Of this
miles about 7 had to be opened up with a road
ilt specially for the purpose, on which supplies
ere hauled by a traction engine and bullock
agons. Power is supplied to portions of the
ork electrically from a central station contain-
g three 65-kw. steam-driven units. There are
motors, varying from 8 to 40 h.-p. connected
th the work. Two of them are used on the
dgerwood cableways and six on the 4-ton trav-
ng cranes. There is also considerable steam-
iven plant. The crushed bluestone used in mak-
g the fine concrete is brought on a narrow-
uge railway from the quarry to storage bins
der a trestle upon which the cars are run in
der that their contents may be dumped directly
to the hoppers. From these bins the stone and
her materials are discharged into a measuring
pper truck and tipped into two box concrete
ixers. Near the mixers there is also a large
ment storage shed from which that material
delivered to the measuring hopper through a
ute. The proportions for the concrete are
2:4 and it has been mixed quite wet. After
ing mixed the concrete falls into steel cars on
track beneath the mixer and is run out by hand
a grade of 1 in 200 to the yard where the
ocks are made. Molds are built in parallel
es, with Koppel turntables at the intersections
th the lines coming from the mixer and the
acks are raised above the bottoms of the molds
stagings filled in with earth, on which the
ils are laid. Arriving opposite the proper mold,
e concrete car is tipped directly into it. The
ncrete is allowed to set for 24 hours and then
e green block is picked up by a traveling elec-
ic crane and carried to the adjoining drying
ound, where the blocks are allowed to season
for two or three weeks before being built into the dam.

Mr. L. A. D. Wade, chief engineer for rivers, water supply and drainage of New South Wales, is responsible for the design and execution of this dam. He has been assisted by Mr. E. N. de Burgh of the same department, who has the principal charge of the work, and Mr. J. Symonds is the resident engineer.

Opportunities and Methods in Electrifying Steam Roads.

At the recent annual "heavy electric traction" meeting of the New York Railroad Club Mr. George Gibbs, chief engineer of the Electrical Division of the Pennsylvania, New York & Long Island R. R., pointed out that among the problems in applying electricity for traction on railways the most important relate to its proper field, the character of the service desired and its cost.

Trunk line service is to-day conducted, irrespective of the character of the motive power, by relatively infrequent and heavy train units, adapted as closely to the public needs as the length of haul, physical conditions, track, safety and reasonable cost of service permit. Electric traction would provide a new motive power, but unless it increases the capacity of the lines, builds up new business which does not now exist, or pays for its adoption by savings in cost, its use is neither logical nor probable in Mr. Gibbs' opinion.

The cost of inaugurating electric traction on a steam railway line has almost invariably been underestimated, he says. Of its very high cost the public is absolutely ignorant, and to the few railway men who have had occasion to inquire into the matter the figures have appeared staggering and the reasons therefor incomprehensible. Electric traction requires power plants of a capacity to take care of the peak load; the trains must be supplied with motive power, which displaces steam locomotives only and at a much higher cost than the latter; an expensive continuous contact system must be constructed over the entire line to supply current from the power plants to the trains. These items foot up to a very heavy total cost per mile of road; but, in addition—and this is a point which is often, ignored by estimators—is the fact that electric apparatus cannot be supplied to an existing steam railroad without many changes in its physical features and equipment. These changes amount in some cases to a virtual rebuilding of the line, and, according to Mr. Gibbs' experience, the electric items making up the equipment of a steam railroad under average conditions are from one-half to two-thirds of the total cost only. Furthermore, it may not infrequently result that a steam railway wishing to electrify and to properly adapt its lines to secure the legitimate advantage of same will be found obliged to double its capitalization per mile; this is a contingency which can be complacently faced by few railways, and does not argue for early or wholesale conversion.

Trunk line service is likely to continue to be conducted by rather infrequent and heavy train units, a system well adapted to the physical limitations of the property. It appears, therefore, that in adopting electricity at heavy cost we must secure operating savings at least sufficient to offset interest and depreciation charges on the added investment. What are the facts as to this? It has been proved that for a reasonably dense train movement (say suburban), the total cost, including general expense but not capital charges, per car mile of passenger movement will be less for electric than for steam power—for very dense movement substantially less. But in average trunk line work, both freight and passenger, it will be found that in handling a given traffic electric operation cannot be made to effect nearly enough savings to justify its adoption on this ground; and in suburban service, which is the legitimate field for electric traction, it will require an extremely dense movement, approximately that of the New York Elevated Road and Subway, to effect operating savings sufficient to offset the added charges.

Electricity will be used, Mr. Gibbs says, in certain large terminals, where reduction of switching will increase capacity, and where safety and cleanliness in tunnels and cities are controlling features, regardless of the great expense. It will be used for heavy mountain grade operation where cheap fuel or water power can be utilized, and powerful electric locomotives may enable the ruling train loads to be taken over the grade without doubling.

Getting there quickly is a vice which is growing upon us. The steam railways are striving to satisfy the demand, and perhaps the statements of railway men as to having reached the limit of capacity in this regard are largely responsible for the rosy promises of electric promoters and the fond hopes of the public. It cannot be too clearly understood that high maximum speed is a function of safety, physical conditions of track and other things. Electric power cannot increase the maximum steam speeds except by altering these conditions. High sustained speed may, in some cases, be attained by electric power, as on a broken gradient and with excessive weights of train, where the possibilities of steam are exceeded, but only at high cost. High average speed in local service with frequent stops is a legitimate field for electric supremacy, and even here a word of caution is necessary.

This high average speed is made possible in electric traction by equipping each car with motors, thus consolidating a large amount of power on the train. This means that the train can be accelerated from a stop with great rapidity and the average schedule shortened over the lower starting rates with steam locomotives. The higher the accelerating rate, however, the greater amount of energy consumed during the accelerating period and the higher equipment costs for motors, transmission line and power house, so that we soon arrive at a point where, by striving after speed, economy, reliability and even safety are sacrificed. We also reach a point where the capacity of the line is affected by increase in speed, because the trains must be spaced farther apart to insure safety, and this means that fewer trains can be dispatched over the same track in an hour.

There has been a tendency for the public to generalize on the advantages of electric traction from too few examples, and this tendency promises to work injustice and hardship to the railroads, Mr. Gibbs believes, unless the growth of electric traction is guided along rational lines. It is certain that heavy electric traction work may be called in the tentative stage at present, and its development must be accomplished for some time to come at heavy cost to the pioneers. Its introduction, as in the case of the terminals in New York City, is sometimes a public and operating necessity, but these conditions do not obtain to like extent in smaller centers of population, and the cost of the introduction elsewhere for like purposes may be easily a crushing burden.

Summing up, if the statements above briefly are well founded it appears that electric traction has solved the city and suburban transportation problems for rapid, convenient and safe movement of a dense traffic; it has been found adaptable to the special conditions of terminal, tunnel and heavy grade work. It has not yet proved its advisability for the movement under trunk line conditions of long-distance heavy train units at infrequent intervals, because of its very high first cost, and because of the lack of stability in methods and appliances for economically and reliably conducting the service. In Mr. Gibbs' opinion the time is far distant when we are ready to discard, even to an appreciable extent, the time-tried steam locomotive in this service; and when the time does come it will be through a radical change in methods from any of those heretofore advanced.

The methods of carrying out electrification must be studied very carefully, according to remarks by Mr. Walter C. Kerr at the same meeting, for many electrification considerations begin by getting tangled in chaotic irrelevant discussion, due to thinking of wrong things first. For instance, discussion of third rail vs. overhead construction, alternating vs. direct current, multiple unit or locomotive traction, or anything to do with the phases, frequency or equipments, are irrelevant in the first instance, when the consideration should be limited only to the broad problem of how, as a traffic proposition, the results produced through electrification will compare with the present steam traction. Engineers of the right kind know how to apply these features quantitatively and qualitatively to general problems in such manner as to determine quickly the advantages or disadvantages of electrification in a given instance; and it is only a waste of time, energy and money to thrash out details that have nothing to do with the general case. Therefore, by a proper process, it can be easily, quickly and cheaply determined whether the present general state of the art warrants electrification or not. If not the job is finished.

If electrification is warranted the next step is determination of the main elements and their applicability to the case in hand. This, again, is not a very expensive or laborious process, if properly handled, and leads to sufficient determination to enable the work to be authorized and the appropriations approximately made to perform it. About this time a good many thank Heaven that the job is done, but this is the time that real work begins.

Before discussing specific methods Mr. Kerr called attention to certain fundamental differences between electric and steam traction. Steam traction consists of specially differentiated units—locomotives and cars—entirely independent units, which can be very unlike in many ways not necessary to specify. With them many forms of operation can be conducted on one track or set of tracks. There is an individuality and uncorrelated relationship between the steam elements which produce the schedule and traffic results.

Electrification, however, is essentially a system in which there is correlation of the highest order. The various parts of an electric traction system are so related and so interdependent as to require a nicety of proportion, identity of characteristic and adaptability of function in many ways, thus requiring a peculiarly high grade of design and construction, because every part of the whole operation is so dependent on every other part and its individual operation. This feature is somewhat against electrification, and perhaps, in brief, can be characterized as requiring greater perfection of the whole in order that any part shall be operative.

Another point of difference is that while a new type of steam locomotive or other steam railway appliance can be tried in a small way before adoption, an electric system must be completely installed, on a large scale, in order that it may exhibit its merits or defects. There must, therefore, be a large expenditure of money, time and power of decision upon the whole electrical plan, and a large amount of faithful constructive work done on innumerable things of widely unlike kind and covering a large area before any part can be made effective for use, or even for practical trial. This calls for exceptional and sustained devotion of engineering and constructive skill on the part of men versed in railway conditions, to the judicious and economical use of capital in performing the work of electrification.

The whole problem is further complicated by the fact that most of the arts involved are exceptionally new and advancing rapidly.

In the general case a steam railway comes to the problem of electrification sufficiently equipped in its departments with men and methods for the established railroad operations, but not for undertaking this large new class of constructive effort in addition. Several courses are then open. They may, through the creation of new departments, acquire the requisite organization to effectively and economically render the engineering and constructive service required. The difficulties in this process are many. The time element is insufficient for perfection of the right type of organization in the first instance. Any aggregation of men, however skilled, is experimental so far as team work is concerned. The arts involved in electrification are so numerous that a small organization is ineffective, while the large one suddenly created contains its own limitations. Another process is to put such work firmly in the hands of an established concern of the type known as engineer constructors, which maintains a large organization covering facilities in every required art. Then, through such organization, carry on the work at first hand as though it were a department within the road. Another method is to employ engineers to make determinations, designs and specifications, and then, with the assistance of such engineers, let segregated contracts for various parts of the work.

Mr. Kerr believes that as electrification spreads to the many steam roads, these properties must in time develop their own several departments fitted to handle all their necessities, just as the present established departments take care of all the needs of a steam system. The best way to develop such departments is through the utilization of an employed department of very nearly like kind. The difficulty and the hazard of creating such departments suddenly is too great to be warranted, in his opinion, nor can any small department thus aggregated bring to the road all of the needful knowledge of the state of the various arts and the practical experience with which to apply them. A large department is not financially warranted, because no road, in the first instance, performs sufficient electrification, nor sufficiently continuous work of this nature, to warrant the general expense of complete facilities; while the capital to be expended is too large and its results too important to be entrusted otherwise than to an assuredly competent and experienced organization.

The character of electrification work requires the correlated work of a lot of men of widely different talent, working co-operatively to bring forth one systematic result, and, therefore, until such time as any road has acquired a sufficient electrical system to warrant the establishment of adequate departments for its operation, maintenance and extension, Mr. Kerr stated that it is better to employ a well-established organization, as a unit, and avail of its entire ability, than to trust to partial methods. Another advantage of this is that it gives the existing departments of any road time to turn around and become, by practical contact, familiar with the new features which they will have to handle, in such manner as to enable much more of the older departmental work to be utilized in the new than would result from the sudden creation of new departments to perform all of the practical things required in the conduct of electrification work.

The general contracting process need scarcely be mentioned here. It is not well adapted to such work. There are no contractors properly organized as to talent, financial responsibility and general all-around quality who can take over in the usual lump sum contract way an entire electrification of a steam system, nor would the departments of an operating road ever be able to live with such contractors were they given opportunity on the right of way to do all they would need to do in their own interests to protect a lump sum bid. The segregation into smaller contracts helps in some respects and hurts in more.

Railroads have learned by long experience how to take care of their own necessities, which essentially consists in taking care of them at first hand. Where so many new things are forced upon a railroad organization as are involved in electrification, the nearest approach to their own first-hand work is to get a helper who has many skilled hands, who then carries on its work in the same spirit and with the same motives and with all diligence, in co-operation with the established departments of the road, and under the full control of the usual administrative heads. The methods of compensation of such effort are well determined and vary through only a small range, based primarily on percentage—sometimes translated into a fixed sum, and sometimes divided between percentage and the payment of certain specified charges.

The main thing in all this is to get the result aimed at, in the most economical and effective manner. Guarantee of results and costs follow from constant and intelligent control, rather than from bids, promises, penalties or legal processes and there is, in Mr. Kerr's experience, no type of engineering operation in which this is so conspicuously true as in the work of electrification.

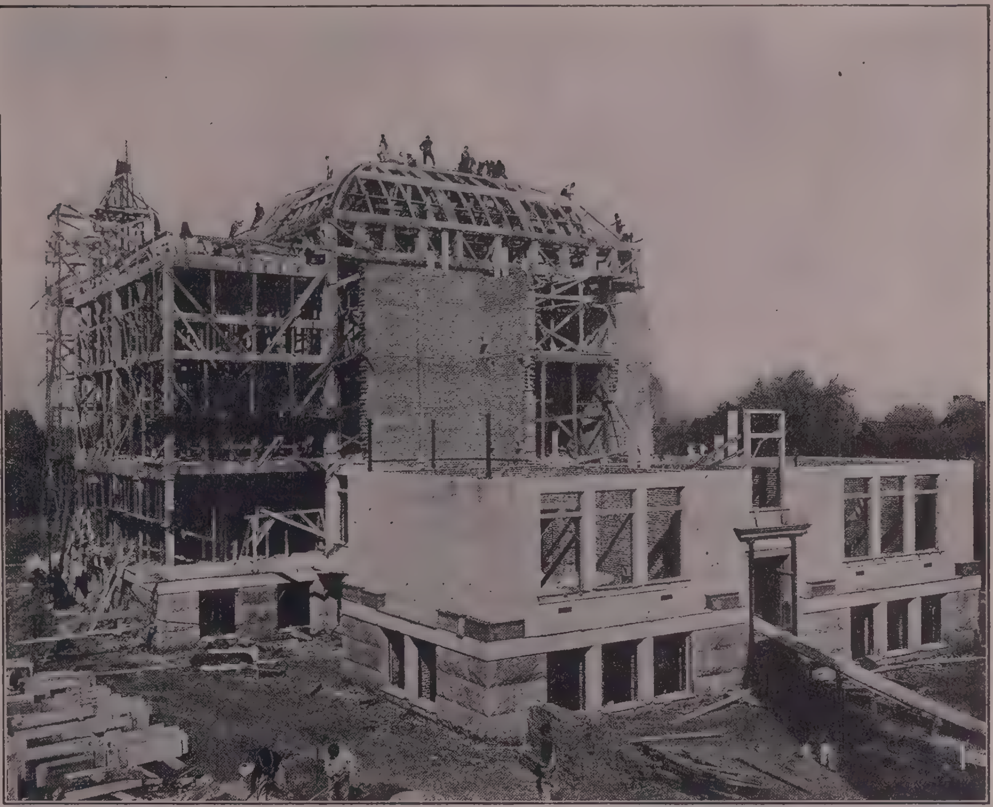
There is not much genius required in the conduct of electrification work, and still less of invention. What is most needed is hard work and lots of it, diligence, faithfulness and orderly procedure, with equal competence given to all parts of the problem, rather than signal ability to certain prominent features and comparative neglect of others. It is essentially team work, which can be only carried on successfully by a sufficient organization, and then only when the whole motive is to work for the client's interest. To this end all selfish, speculative or other interests must be put aside, which thus far has been found best done by fixing and insuring a modest compensation, rather than exciting the hope of large gain.

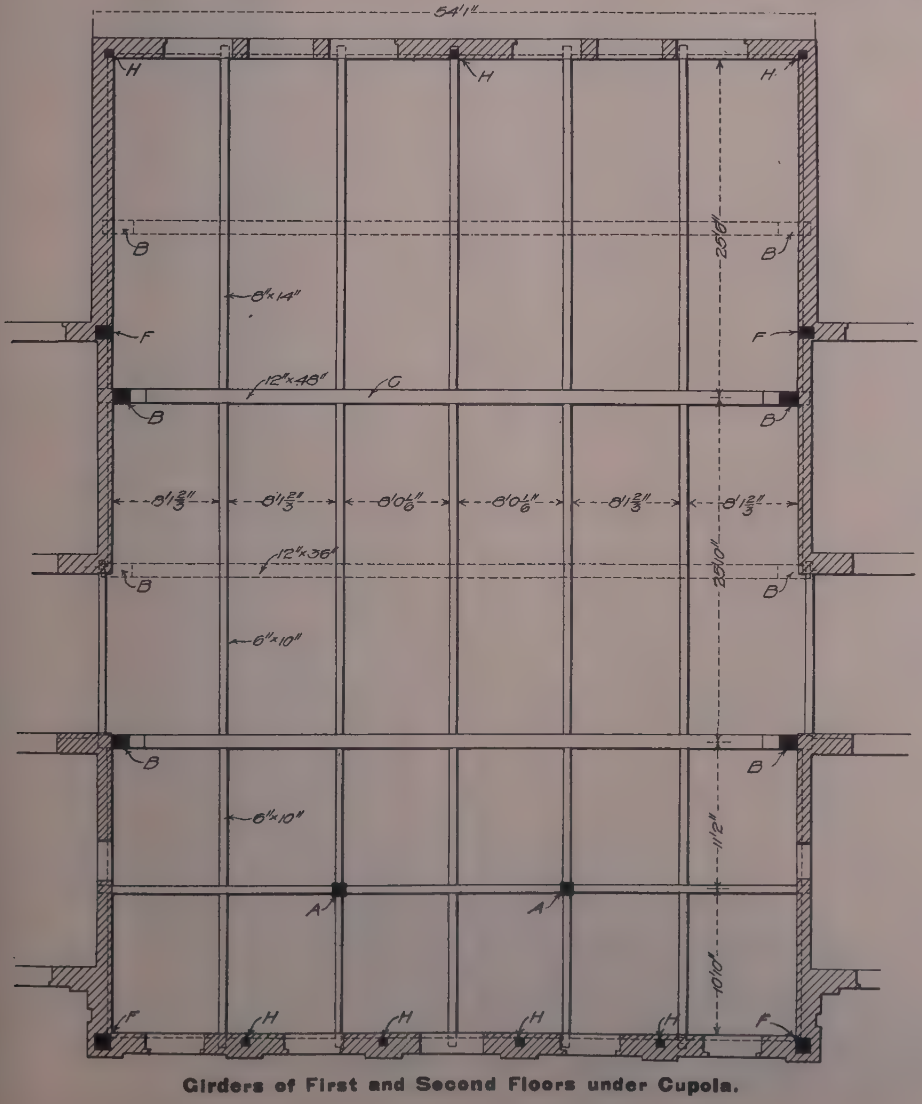
The Introduction of Water Meters on the services of some of the houses in Washington has been followed by complaints not at all unnatural when the deep aversion to such devices in the national capital is recalled. For many years the opposition to meters was so strong that none could be placed, but not long ago Congress appropriated a sufficient sum to place meters on the services of such houses as the District Commissioners selected. In order to save the property owners all possible inconvenience the meters are being placed outside of the houses, generally in the tree-strip which separates the roadway and sidewalks of the streets. There are occasional difficulties in following this plan, as where the street is wide and the water mains are laid inside the sidewalk line on both sides of it. In such a case it is necessary to put the meter in the private lawn of the property. Other cases arise where there is a single line of water pipe laid from the street main to the lawn of some property and then branches are carried off to several houses. All these complications are being solved by the District Commissioners as they arise with a view to causing the least possible inconvenience to the owners, for it is hoped that in this way the feeling against meters will be very materially reduced, particularly when experience with them proves their value to householders as well as the wattr department. The opposition now shown is not at all serious, and due mainly to lack of knowledge of the Commissioners' intentions.

Structural Details of the Holy Angels School, Buffalo.

The Holy Angels School, Buffalo, is an 86x162-ft., three-story building, which is interesting as an example of reinforced construction combined with brick and stone walls. It illustrates the adaptability of reinforced concrete construction to elaborate and difficult framing and presents examples of long span heavy girders, of so-called trusses without diagonal members, and of a wide span groined arch or square cupola with framing resembling closely what would be adopted for wooden construction yet made entirely of reinforced concrete.

The floor plans substantially resemble the roof plan except in the location, arrangements and dimensions of the girders which are adapted to the different loads and are lighter under the loads required for the roof. The general construction and arrangement of the floors and floor girders is not of unusual type, but the architectural requirements for the roof necessitated some unusual construction in its members. It essentially consists of the large curved cupola over the central hall, of a comparatively flat pitched roof in the rear, of double pitched roof on both sides and pitched roofs over the end wings. The intersections of the different curved and inclined planes made complicated construction which was the more difficult on account of the long spans and heavy loads demanded for some of the members. All beams and girders, floor and roof slabs are of reinforced concrete construction and the former are supported partly on the walls and partly on the columns, all of which are of reinforced concrete, excepting four cast-iron columns, which carry part of the gallery floor. The building is therefore largely of cage construction which enabled the framework to be completed before all of the exterior walls were built.


Holy Angels School, Buffalo, under Construction.



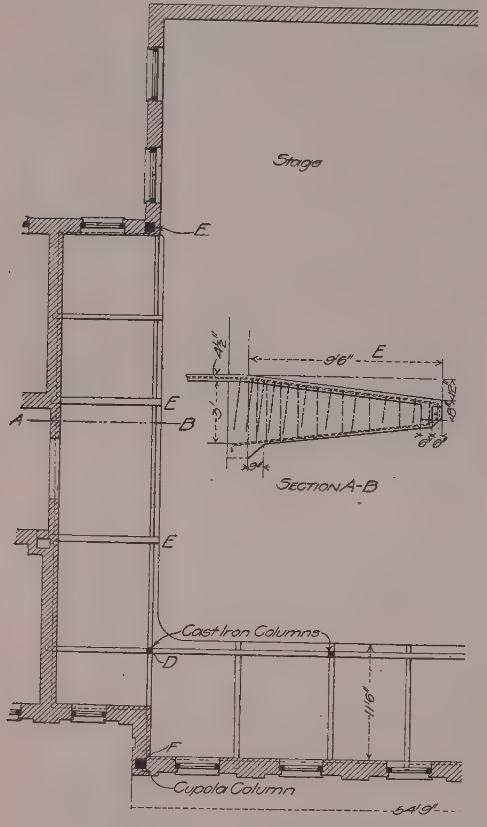
Girders of First and Second Floors under Cupola.

In the center of the building between the two wings is an assembly hall having an area of 4,475 sq. ft. This space is used, in the basement, for a drill hall and care was therefore taken to leave it free from obstruction by columns except for two comparatively small reinforced concrete columns about 17 ft. apart on centers which were necessary to carry a third floor balcony. Except for the balcony there is no platform at the third floor level under the dome, but the first and second floors in this part of the building are carried by long longitudinal girders supported independently of the wall by 8 reinforced concrete columns as indicated in the part plan. Up to the first floor all of these columns have a uniform 12x18-in. cross-section and support the four first floor longitudinal girders, 12 in. wide and 40 in. deep, inclusive of the 4-in. floor slab. The girders have a span of about 53 ft. and the heaviest one is reinforced with four 1⅜-in. bars and four 1¼-in. bars in the lower edge and two 1-in. bars in the upper edge. The floor slabs 4 in. thick have maximum dimensions of about 8½x13 ft. and are reinforced by ½-in. rods 18 in. apart. They are carried by maximum floor beams 8 in. wide x 12 in. deep, exclusive of the thickness of the floor slabs, and are reinforced by two straight 1⅛-in. bars and by one bent 1-in. bar with the ends reaching to the upper edges of the beams.

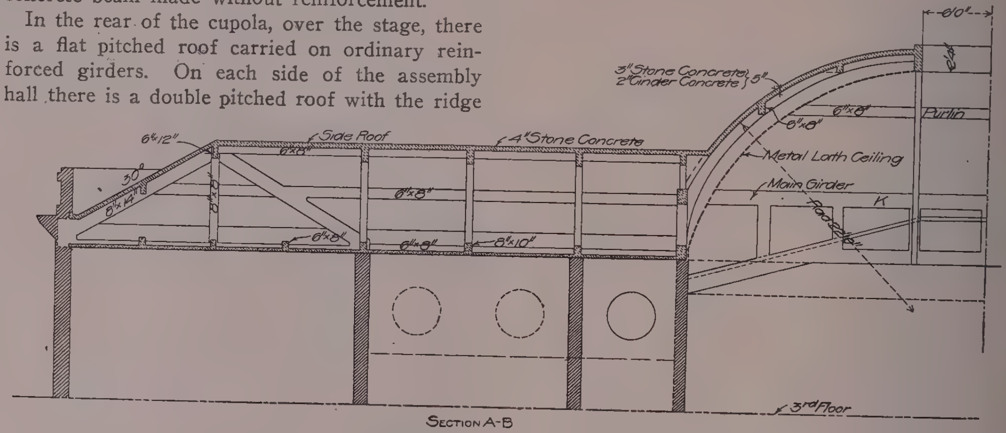
Four of the interior columns, B, B, etc., in the assembly hall area terminate at the first floor. The other columns continue to the second floor with a uniform cross-section of 12x16-in. and support two main girders 55 ft. long and 25 ft. apart in the clear parallel with the longitudinal axis of the building. One of these girders supports loads from floor panels 25 ft. wide on each side. It is 12 in. wide and has a depth of 4 ft., exclusive of the 4½-in. floor slab on top. It is reinforced with three 1¾-in. straight rods and three 1¾-in. bent rods in the lower side and with two 1¼-in. straight rods in the upper side. Shear is provided for by two rows of vertical stirrups from 4 to 18 in. apart. The main girders carry transverse floor beams about 8 ft. apart in the clear and from about 10½ to 25 ft. long. Their maximum dimensions are 8x12 in., exclusive of the floor slabs, with a reinforcement of three 1-in. straight bars and three ¾-in. bent bars in the bottom edge. The reinforcement bars in all beams and girders have short right angle bends at both ends to secure better engagement with the concrete.

The assembly hall is two stories in height, extending from the second floor to the cupola roof. The third floor therefore terminates in the planes of the girders supporting the assembly hall roof and a portion of the third floor 9½ ft. wide adjacent to the assembly hall on three sides serves as a balcony with a surface slightly inclined downward to provide for the pitch of the seats. In the front of the building one side of this balcony is carried directly by the outer wall and the inner edge is carried on three slender cast-iron columns seated on the top of the reinforced concrete columns at the second floor level. On the two adjacent sides the balcony is supported by pairs of reinforced concrete cantilever brackets 9½ ft. long, which are anchored to the inner longitudinal walls 13 ft. apart in the side wings of the building. The brackets, 8 in. thick, have a depth of 3 ft. at the wall and 1 ft. at the outer extremity; the lower edge is reinforced with two ⅞-in. rods and the upper edge with one 1-in. rod, all of them being extended into the wall. The angle between the lower edge and the wall, like that with the main girders, is filleted with a solid mass of concrete 8 in. deep and 8 in. high forming a short kneebrace or corbel. The outer ends of the brackets are connected by a 6x9-in. concrete beam made without reinforcement.

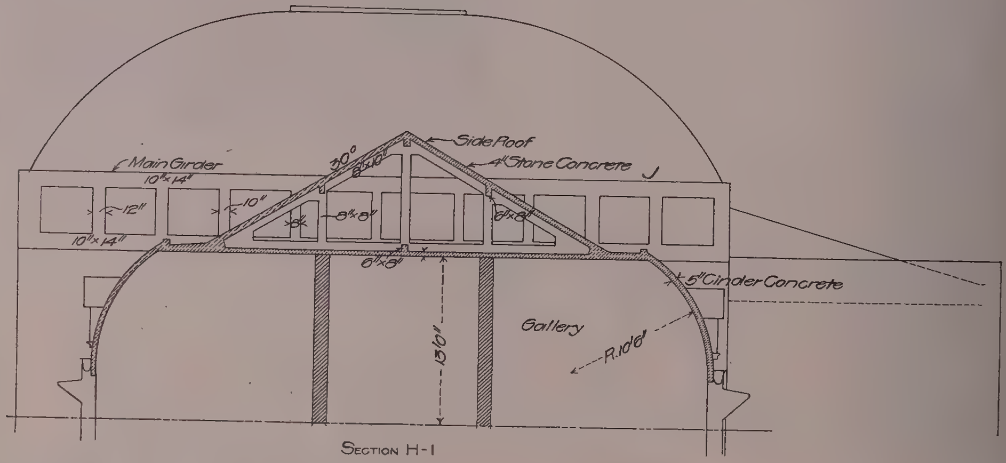
In the rear of the cupola, over the stage, there is a flat pitched roof carried on ordinary reinforced girders. On each side of the assembly hall there is a double pitched roof with the ridge transverse to the longitudinal axis of the building supported by simple triangular trusses with inclined top chords forming rafters and horizontal bottom chords connected to the top chords by vertical posts without diagonals. The ends of the roof are constructed with the slope parallel to the longitudinal axis of the building and the roof is there carried by rafters inclined in one direction only. The tops of these rafters are braced by inclined struts symmetrical with them and forming with the ceiling beams triangular trusses similar to the transverse ones already described.



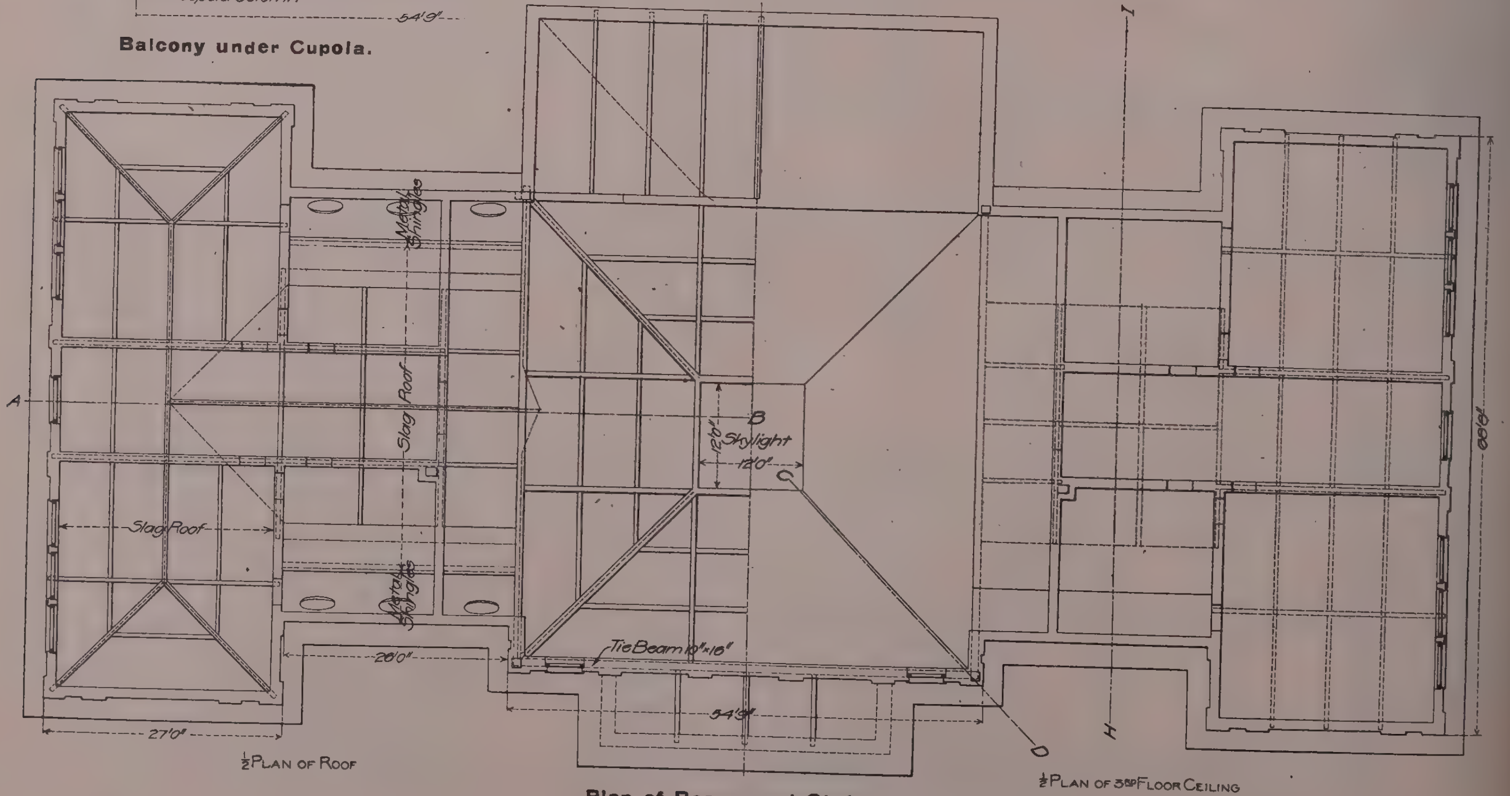
Balcony under Cupola.



Section A-B



Section H-I



½ Plan of Roof

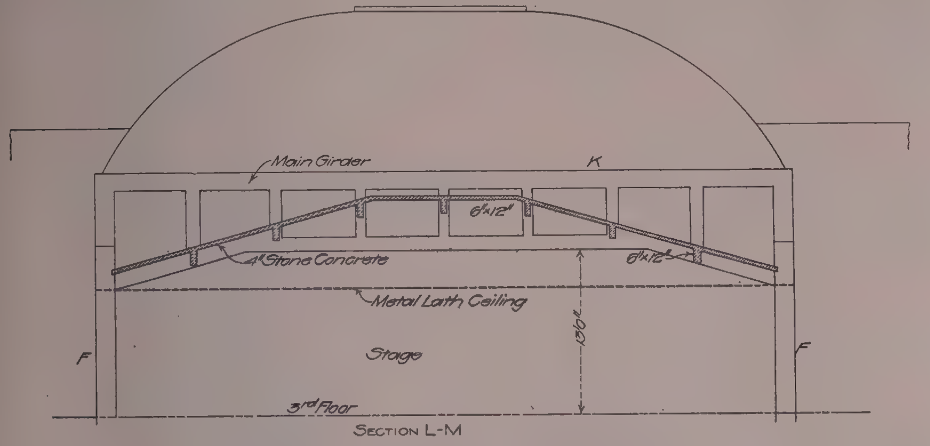
½ Plan of 3rd Floor Ceiling

Plan of Beams and Girders.

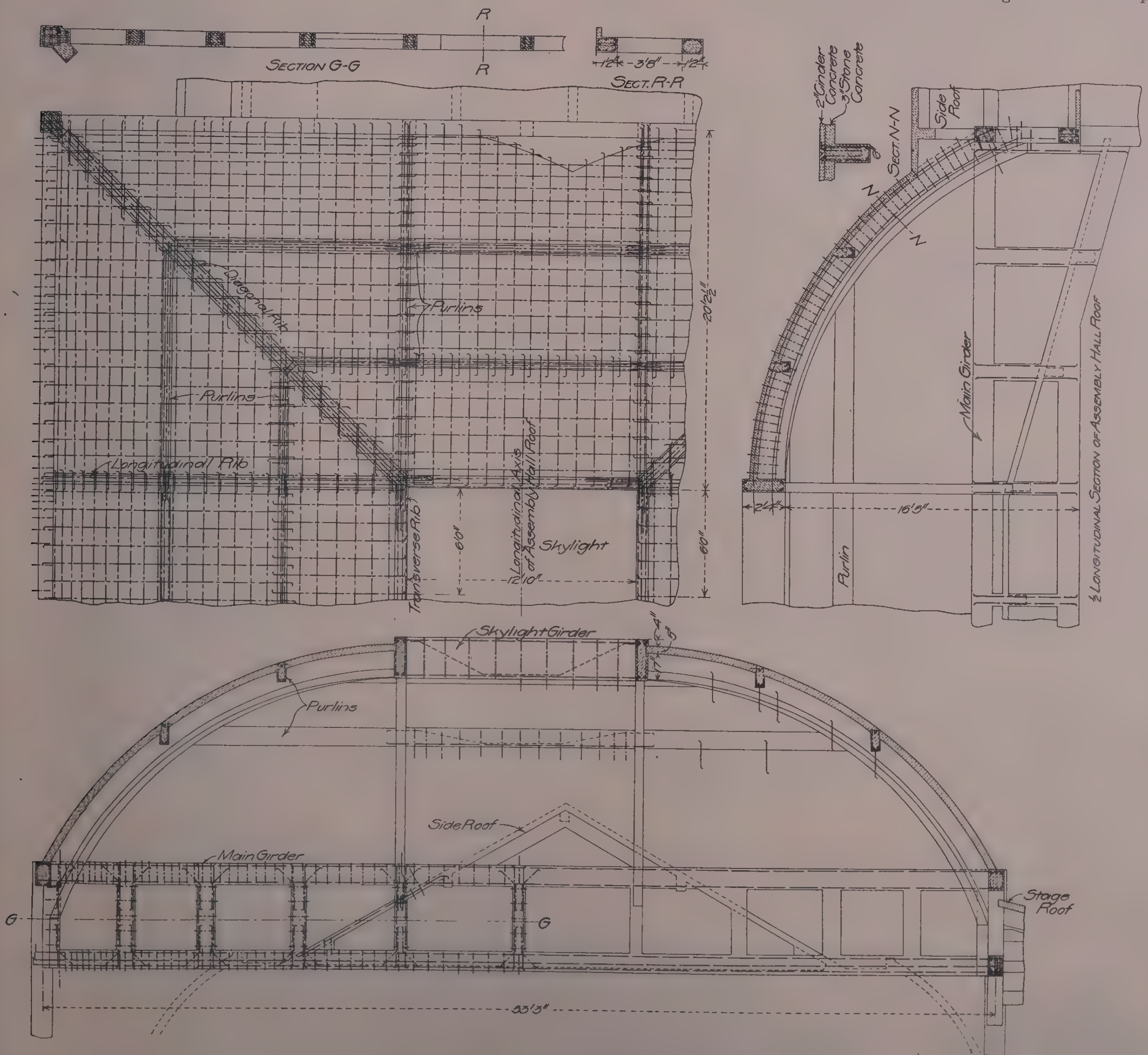
As the assembly hall is not enclosed on three sides by walls it is necessary to carry the square cupola roof over it on girders or trusses which are of a peculiar type made with open rectangular panels and not having diagonal members necessary to constitute perfect trusses. These main girders support the continuous lower edge of the cupola arch on three sides; on the fourth side it was originally intended that the roof should be supported by the Indiana limestone front wall of the building. As considerable delay was experienced in building this wall it was finally decided to carry the roof instead on intermediate reinforced concrete steel columns, H, H, etc., which were built in the plane of the wall and enabled the roof to be constructed without additional delay and were afterwards permanently enclosed in the wall. The three main roof girders are carried by four 14x14-in concrete columns, F, F, one at each corner of the assembly hall and each reinforced by four 1-in. and four ⅞-in. bars. These receive the very heavy roof loads independent of the light brick piers which are not strong enough to carry it.

The two transverse girders supporting the cupola are 6 ft. deep over all and 53¼ ft. long on centers of columns. The top and bottom portions correspond to the chords of a perfect truss and are both 10 in. x 14 in. deep and are reinforced by four and by six 1⅜-in. straight rods in the upper and lower surfaces of each. They are connected by vertical members about 3 ft. apart at the ends of the truss and about 6 ft. apart at the center of the truss. The latter are each reinforced by four ⅞-in. or 1-in. vertical bars and by horizontal bars or hoops and have at both ends bent bars like kneebraces engaging the chord pieces obliquely. The shear in the chord is provided for by stirrups like those of a regular beam which are spaced from 4 to 10 in. apart. The ends of the top and bottom chords are integral with the supporting concrete columns to which they are bonded by the bent ends of their reinforcement bars, but they do not have fillets or kneebraces at their intersections with the columns.

There are in the cupola two main arch ribs parallel to the longitudinal axis of the building and 12 ft. 10 in. apart, symmetrical with the center line. There are also two corresponding transverse ribs 12 ft. apart and the rectangle enclosed between their intersections forms an open well covered by a skylight over the center of the hall. Similar diagonal ribs like hip rafters



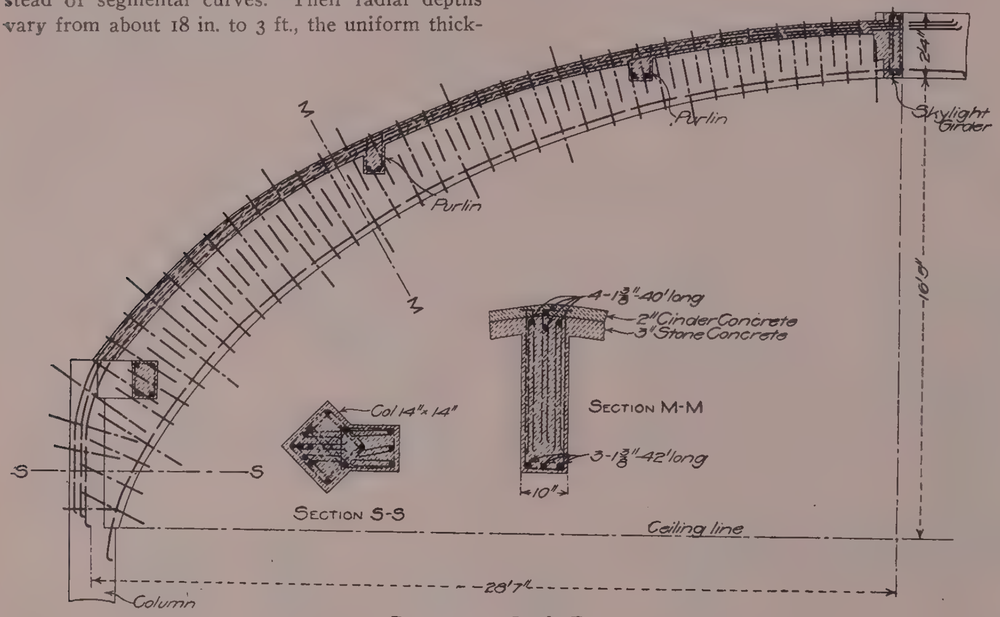
Transverse Section of Roof over Wing.



Part Plan and Sections of Cupola.

run from the corners of this rectangle to the corner columns supporting the roof. The ribs are connected by two intermediate sets of horizontal longitudinal and transverse purlins parallel to them and forming rectangles concentric with the skylight well. Parallel rectangular girders connect the upper ends of the ribs and form a curb for the skylight, corresponding to the drum of a dome. The roof slab, 5 in. thick, is integral with the arch ribs and perlins and is made with a 2-in. interior layer of stone concrete and a 3-in. exterior layer of cinder concrete to which the roof tiles are nailed. Vertical steel hanger rods are built into the ribs and purlins and project below them with bent hooks at the bottom to receive the ceiling framework.

The transverse and longitudinal arch ribs have a uniform depth of 12 in. normal to the roof slab and their lower edge is curved to a radius of 21 ft. 4 in. They are reinforced by two 1-in. bars in the upper and by two ⅞-in. bars in the lower part and have radial stirrups spaced at a uniform distance of 12 in. apart. The diagonal ribs are similar to the longitudinal and transverse ones except that their dimensions are greater and that they have, of course, elliptical instead of segmental curves. Their radial depths vary from about 18 in. to 3 ft., the uniform thickness being 10 in. The span is 28 ft. 7 in. and the rise of the intrados is 16 ft. 5 in. Each rib is reinforced with four 1⅜-in. bars near the upper and three 1⅜-in. bars near the lower surface and has the usual normal stirrups. The purlins are all 6 in. wide and about 8 in. deep, exclusive of the roof slab, with one ½-in. bar in the top and two ⅝-in. bars in the bottom. The skylight girders uniting the tops of the ribs are 28 in. deep and 8 in. thick and are each reinforced by top and bottom bars. The roof slab is uniformly curved to an exterior radius of 32 ft. 9 in. and is reinforced by horizontal 5/16-in. bars 12 in. apart and by curved ¼-in. bars at right angles to them 12 in. apart. The mansard roofs on each side of the assembly hall are made with solid curved slabs of cinder concrete 5 in. thick and act as arch segments without stiffening ribs, seated continuously on the side walls of the building and abutting, at their top against horizontal girders or curbs along the outer edges of the flat roof. They are curved to an inside radius of 10 ft. 6 in. and have a rise of 8 ft. 10 in. They are reinforced with horizontal and curved 5/16-in. rods 12 in. apart, at right angles to each other. They are pierced with windows 3 ft. 9 in. in diameter and each opening is reinforced with two 5/16-in. circular rods and 12 short radial stirrups. The principal quantities include 710 cu. yd. of stone concrete and 45 yd. of cinder concrete, both made 2 : 3 : 5, with Alpha brand Portland cement. The concrete was mixed in a Smith machine and hoisted by an American hoisting engine elevator to the required height, where it was distributed to the moulds by wheelbarrows. About 60 tons of plain round reinforcement bars were used, which were bent as required at the building. About 40,000 ft. b.m. of hemlock was required for the falsework and centering. Mr. A. O. Von Herbulis, Washington, was the architect. The Brennan Construction Co. was the general contractor and the concrete construction was designed and erected by the Baltimore Ferro-Concrete Company. Mr. H. J. West, president, and Mr. Henri Kampmann, C.E., treasurer.



Details of Arch Rib.

A Prize Competition.

A prize competition for designs for quays for the proposed Sannegardsviken freight harbor at Goteborg, Sweden, has been announced by the Harbor Board of that city. The basin of the harbor is to have a depth of 8 meters. Plans may be submitted for both permanent and temporary works, gor quays with the full depth alongside them, and for protected slopes. In case the latter is given prominence, the provisions for mooring and protecting ships and for the future construction of works utilizing the space more economically must be stated. The quays must furnish room for three parallel standard-gauge tracks, with space back of them for coal and bulk freight, and provide for the use of large traveling bridge cranes along their length. The plans must give a complete design of the proposed work and be accompanied by a description of the method of execution. The plans will be examined by five judges, two of them members of the municipal works department and the remaining three officers of the national railway and waterway corps. In judging the projects the suitability, stability and cost of the proposed works will be taken into consideration. Three prizes of 2,500, 1,500 and 1,000 crowns are offered, and any plan which does not receive a prize, but is desired by the Harbor Board will be purchased for 500 crowns. The competition closes at noon, Sept. 2, 1907, and those desiring to participate may obtain the necessary plans and papers by sending 10 crowns to the "Stads Byggnadskontor" of the city. The proposed works present an unusual opportunity for original design and in recognition of this fact the authorities have determined to hold this international competition, in order that harbor specialists everywhere may have an opportunity of presenting their views.

Meadow Roads in Cape May County, N. J.

For several years past Cape May County, N. J., has directed its attention, in the line of road improvement under State aid, to the construction of public roads, connecting the various seashore resorts with the mainland of the county. These summer resorts are located on the beaches along the Atlantic coast and are separated from the mainland of the county by a wide expanse of salt marsh and inland waterways. The marshlands consist of deposits of soft mud, frequently 25 ft. in depth, overlaid by a sod or crust of sedge or grass roots. In many places this crust is not sufficiently strong to support a horse.

To construct a roadway across this marshland that will be adequate for the travel as well as up to the standard required by the State, is not an easy task, and the problem is made more difficult by the fact that materials must be used that will not overload the meadow crust and cause settlement, and at the same time will withstand the wash of storm tides, which frequently overflow these roads and marshlands.

The first of this class of roads, constructed under State aid, according to Mr. R. Fendall Smith, county engineer of Cape May County, was the Rio Grande and Holly Beach road, followed later by the Marmora and Ocean City road, and, in June, 1906, the work of constructing the road from Ocean View to Sea Isle City was begun. This was built on the line of an old causeway, which had been used as a roadway for more than twenty years, and comprises two miles of meadow and six-tenths of a mile of upland roadway.

The principle on which these roads are constructed is as follows: A foundation is laid of poles and stringers of sufficient area to support the weight of the filling soil and pavement, together with the added weight of travel without breaking down the meadow crust. The sides are protected from wash by curbing and bulkheading throughout the entire length, on both sides of roadway, and also by a continuous line of mud banks solidly compacted against the outer side of the curbing. A new feature introduced into the construction of the Sea Isle road is a "tie" placed every 3 ft. under the pole foundations at right angles to the center line of road. These ties are spiked or bolted to the piling supporting the side curbing or bulkheading, and thus they securely bind the two lines of curbing together, prevent spreading of the roadway, and, at the same time carry a part of the weight of the roadbed to the piling, which in turn assist in carrying the weight, forming, in reality, an underground trestle on which the stringers and poles are then placed, the same as in the two other roads.

After the pole foundations are properly laid, upland soil is filled in between the lines of curbing, until the required elevation is reached, after which the pavement of shells and gravel is spread over the roadway, bringing the finished surface up to an elevation of 2 ft. above the mean high water line.

The most satisfactory paving materials found thus far are oyster shells spread 5 in. deep and covered with 4 in. of good gravel. This forms a pavement, light in weight, which withstands the wash of storm tides, and does not rut up badly when the roadway is soft from storm tides or the effects of frost.

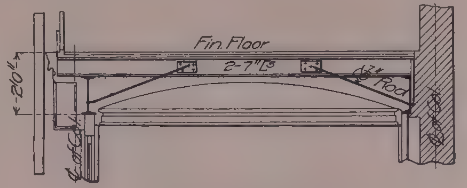
Self-Propelled Cars are operated by the principal steam roads in England and by some roads on the Continent, according to the committee which has been investigating the matter for the Pennsylvania R. R. Both gasoline and steam-propelled cars are in use. While in England the system has proved quite successful as a feeder to the through main line trains, it is still regarded as an experiment on the Continent.

The National Shawmut Bank Building, Boston.

The eleven-story building for the National Shawmut Bank of Boston occupies the block on Water Street, between Devonshire and Congress Streets for a depth of 85 ft. The Water Street elevation is 180 ft. wide, with a 24x85-ft. light court in the middle.

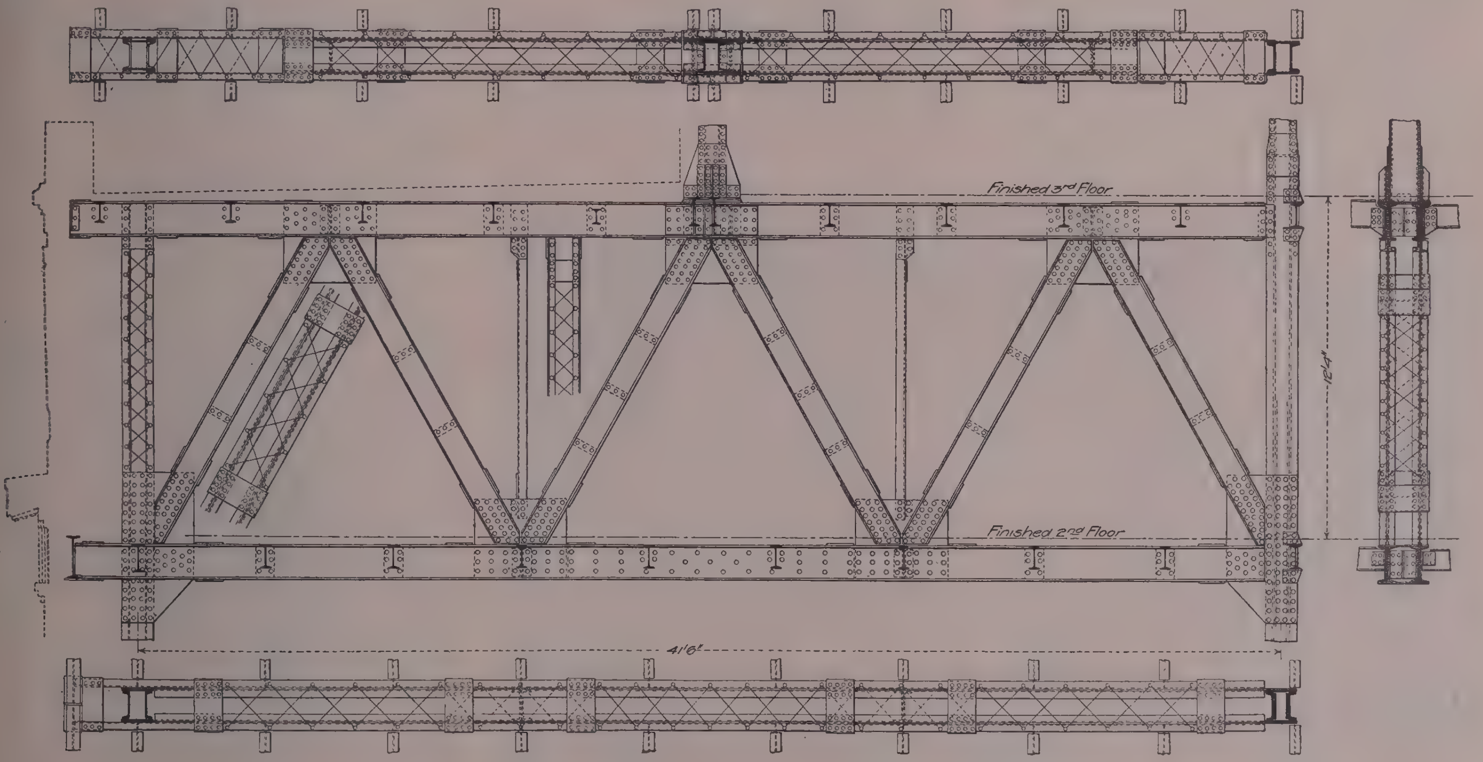
The exterior walls are built of brick, faced with granite on the outside and marble on the inside in the first and mezzanine stories. These walls above the second floor are carried on steel beams. Below the second floor they are self-supporting, and rest on the granite retaining wall, which is continuous around three sides of the building. This retaining wall also serves as a footing for all the exterior columns. Along one-half of the rear of the building is a massive concrete retaining wall about 10x12 ft. in cross section, which holds back the thrust from an adjacent eleven-story building, the bottoms of the footings of which are about 10 ft. above the base of this wall. On this wall also rest several of the columns of the building.

The building is carried on a steel frame, consisting of 72 columns, arranged in longitudinal and transverse rows, and between which are girders for supporting the walls and floor beams. These columns are made up of plates and channels, which have bearings on cast-iron pedestals from 16 to 36 in. square, which in turn rest either on concrete footings, capped with granite levelers or on I-beam grillages.

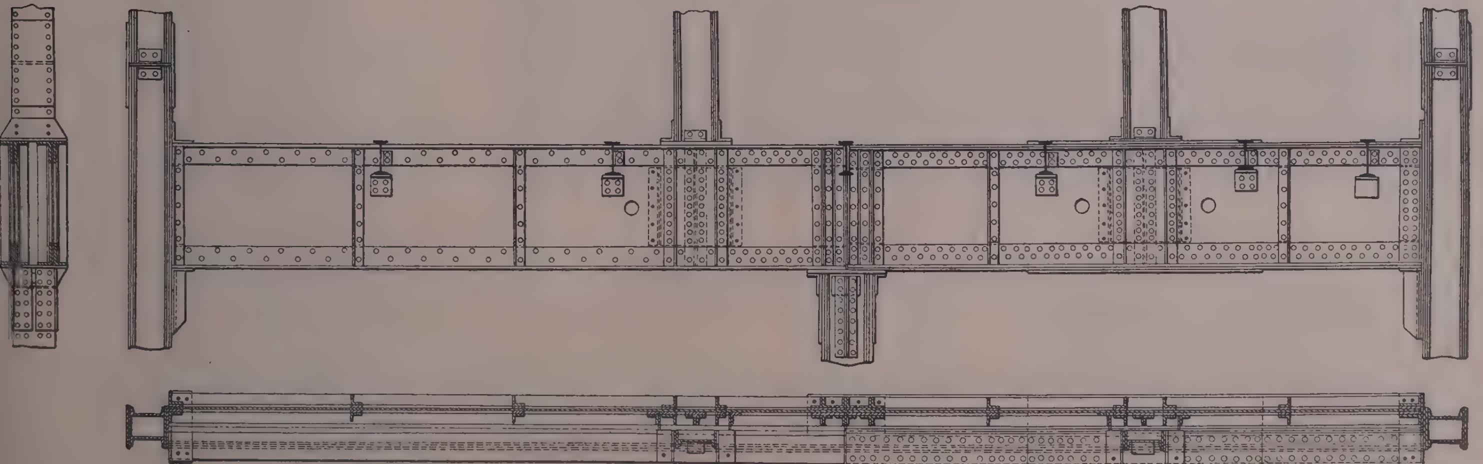


Ties for Ceiling Arch Thrust.

The plans from the 2d floor up are framed with 12 and 15-in. girders, and 8, 9 and 10-in. I-beams, carrying 10-in. flat terra cotta arches. The first and mezzanine floors in front of the elevators are of arch construction with spans of about 11 ft. The thrust of these arches is resisted by inclined tie rods secured to transverse beams above the crown of the arch.



Main Truss in Second Story Carrying Upper Columns.



Twin Girders Carrying Upper Columns.

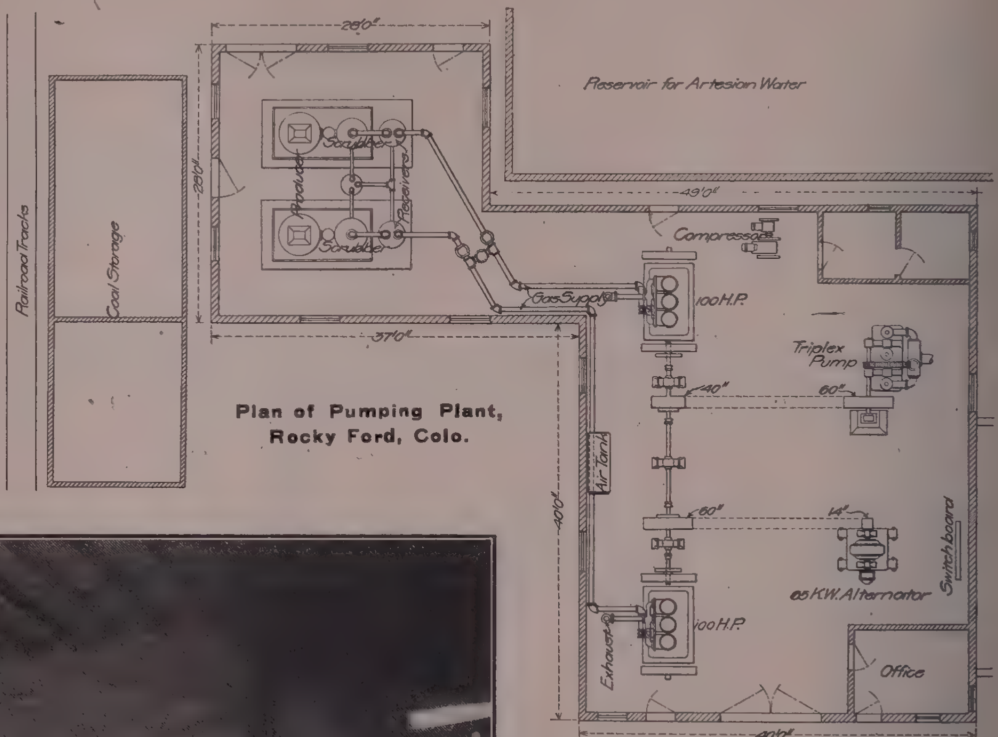
In order to provide for a first-story banking room which should be unobstructed by columns, the exterior columns in the center of the Water Street elevation are carried by four transverse trusses of 41½-ft. span. These trusses are of such a depth that their bottom chords are in the framing of the second floor, while the top chords are in that of the third floor, the web members being so arranged as to permit of doorways in the second story partitions, which completely enclose the trusses. These trusses are four in number, and are 12 ft. 4 in. deep, with three 13 ft. 10 in. panels. The web members are inclined, and there are light vertical struts to relieve bending in the top chord. The chord members are made up of four 15-in. channels in pairs, latticed together, the bottom chord being reinforced in the center panel by a 14½x⅝-in. web plate. The diagonal members are made up of four 12-in. channels, latticed together and connected to the top and bottom chords by ⅝-in. gusset plates. In order to equalize the loading, riveted separators are provided at each panel point. The chords with gussets were shop-riveted and shipped full length; the web members being shipped separately, and all connection rivets were field driven. The gussets forming the end connection were shop-riveted to the supporting columns. The top and bottom chords serve as girders for carrying the second and third floor beams. The position of the columns at each end of the banking room, being fixed by the architectural features of the room, the columns at these points above the second floor are carried on pairs of plate girders, each pair consisting of two 33½x7/16-in. webs and eight 6x4x¾-in. flange angles.

There are 1,250 tons of structural steel required in the frame. Messrs. Winslow & Bigelow, of Boston, are the architects. Messrs. Purdy & Henderson, of Boston, New York and Chicago, were the engineers who designed the steel and foundations and prepared the shop drawings for all the structural steel. L. P. Soule & Son, of Boston, are the general contractors. The steelwork was fabricated by the New England Structural Co., of Everett, Mass., and erected by the general contractors.

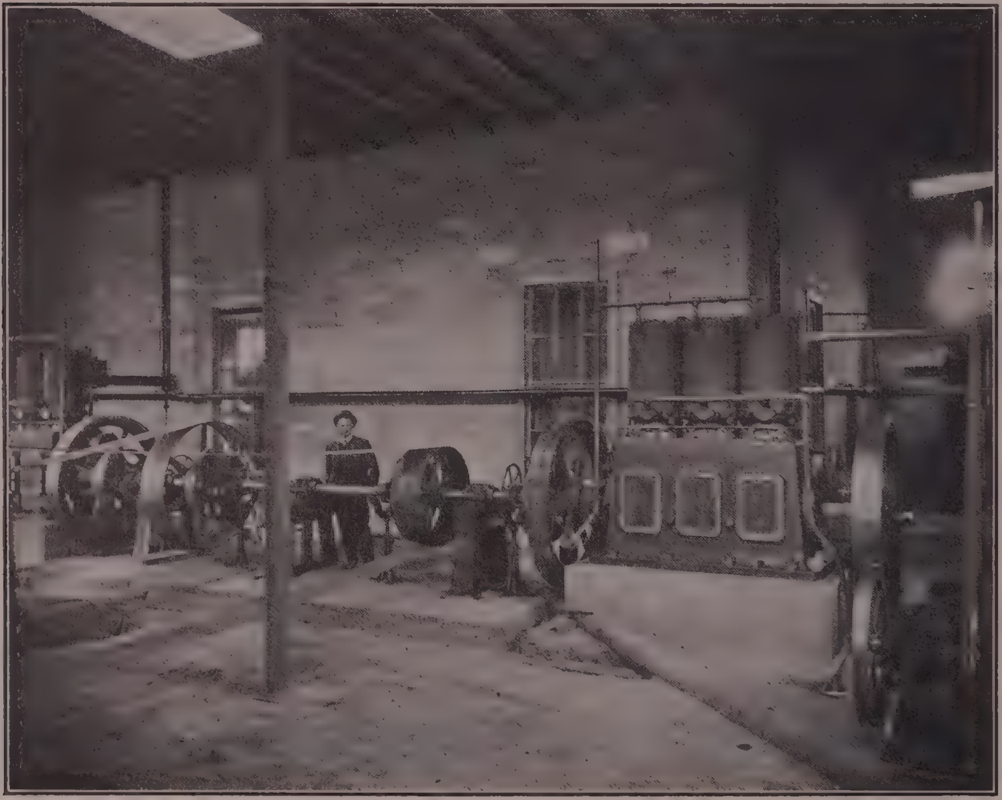
Producer Gas Engine Pumping Plant at Rocky Ford, Colo.

Rocky Ford is a city of about 2,000 inhabitants in the southeastern part of Colorado, about 50 miles east of Pueblo. It has a gravity water supply furnished by two reservoirs with an aggregate capacity of 1,500,000 gal., which are located 96 ft. above the city. These were formerly fed by artesian wells, but with the recent growth of the city and extensions of the system this supply became inadequate. The supply has recently been increased by the installation of a 1,000-gal. pumping plant, drawing from driven wells, which is operated together with a new electric lighting equipment by a producer gas power plant.

The plant is housed in a concrete block structure on concrete foundations, having a 40x52-ft. main building for the engines and pumping and electrical generating equipments, and a smaller building 28 ft. square, at the rear and at one side, for the gas producer plant, the two being connected by a 12-ft. passageway. The building is finished with concrete floors and a wooden roof with skylights for light and ventilation. In the front of the engine room an office, bath and dressing rooms are provided for the convenience of the attendants. Fuel is stored in a 14x40-ft. building at the rear of the producer house, which adjoins a side-track from the railroad permitting shoveling coal directly from cars into the bin. This house provides for the storage of over 100 tons of fuel; this is wheeled into the producer house in buckets which are hoisted by a jib crane on the elevator charging platform from which they are dumped directly into the producer charging hoppers.



Plan of Pumping Plant, Rocky Ford, Colo.



One of the Gas Engines and Shafting.

There are two Weber gas producers of 100 h.p. each, centrally arranged in the producer house with an elevated platform for access to the charging hoppers. Each outfit consists of a producer, a scrubber and a receiver, which is connected to deliver gas through a 4-in. line to a corresponding gas engine in the adjoining room. The producer equipments are installed in duplicate, as are also the engines, so that two complete and independent power plants are secured, a cross connection between the gas pipe lines permitting each producer to operate either engine. The producers are specially arranged for operation with Colorado anthracite, an inferior grade of anthracite coal. These were installed under a fuel consumption guarantee of 1¼ lb. of this fuel per horsepower-hour, but it is stated that they have been operating since the completion of the plant on about 1 lb. per hour.

The producer consists of a cylindrical steel shell, lined with fire brick and fitted with a grate, and has a charging hopper at the top and a hand blower. It is also fitted with a small drum or boiler, through which the hot gases travel to the scrubber, thereby creating the steam which is necessary to supply hydrogen to the gas. The cylindrical scrubber is used for cleansing the gas and cooling it, the gas, after leaving the boiler, flowing through a water bath at the bottom, and then up through the scrubber proper, which is filled with coke and covered by a continuous spray of water. It is then delivered to the gas receiver and is ready to be used in the engine.

The two engines are of the three-cylinder vertical Weber type specially designed for operation with suction gas. They are located at opposite sides of the rear of the engine room and direct-connected to a short jack-shaft from which the pump and generator are belt-driven. The jack-shaft is a 5-in. steel shaft, 20 ft. in length, which connects through a friction clutch at either end to the fly-wheel of one of the gas engines, thus permitting the load to be transferred from one engine to the other at any time. This arrangement also facilitated connections to the gas mains from the producers, which are brought into the engine room at an elevation of about 7 ft. above the floor level. The exhaust connections are 5-in. lines carried from the cylinders of either engine through the roof independently.

The engines have cylinders 14 in. in diameter by 15 in. stroke, and operate at 280 r.p.m. The ignition system is of the positive make and break or "hammer" type, the current being supplied from friction-driven magnetos. The engines are governed with a ball governor driven by a secondary shaft, the governor actuating special intake valves which act directly on the air and gas by throttling. Lubrication is accomplished by the splash system, the crank case being enclosed and filled with oil. The engines are started by compressed air, which is furnished by a 5-h.-p. gasoline engine, direct-connected to an air compressor. This engine is ordinarily started by hand for supply of air pressure in starting a producer, and the air is stored in a 24x72-in. cylindrical tank. It is also connected by belt to an exhaust fan which is of service for quickly building up the fires in a producer in starting, so that while the compressor is developing sufficient air pressure for starting an engine, the exhauster may be used to force the fire in the producer so that both parts are made ready for use at the same time.

Both the pump and the generator are driven by pulleys mounted on quills on the jack-shaft and connected to it by friction clutches operated by floor-stand wheels at the rear of the shaft. The generator is a 65-kw. Bullock alternator, supplied by the Allis-Chalmers Co., which is wound to deliver at 2,200 volts direct to the distribution lines. It has a four-pole exciter direct-connected to the generator shaft. This unit is used for both street and commercial lighting in the city.

The pump is a 12x14-in. Deane triplex pump rated at 1,000 gal. per minute against a pressure of 100 lb. It has a 12-in. suction from the wells and delivers to the mains through a 10-in. line. The pressure carried normally is 40 lb. on the main, which is raised to about 100 lb. direct pressure for fighting fire. In tests that have been made fire alarms have been turned in when one engine was driving the generator and the pumps were delivering at 40 lb. pressure to the system. The pressure was immediately raised from 40 to 100 lb. Under such conditions the duplicate engine of the plant has repeatedly been put in operation and the load shifted from the other engine in not over five minutes, and with a variation of water pressure of less than two per cent. during the change. Under repeated test the engines have shown themselves capable of withstanding changes from no load to full load with variations in speed of less than two per cent., and with the duplicated arrangement of equipments throughout, one always serves as relay to the other for immediate use in case of a fire alarm or accident.

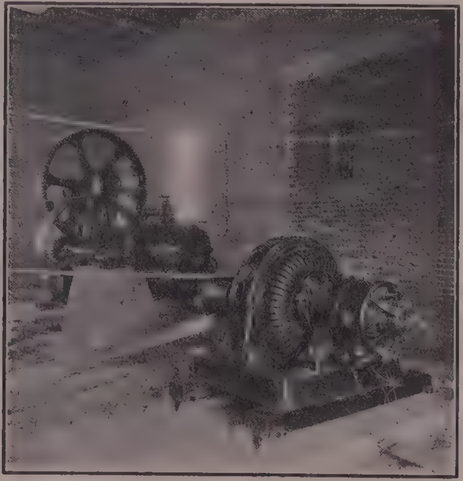
Gas Producer Plant.

The entire power equipment of the plant, together with the generator and pump, were installed by the Weber Gas Engine Co.

AN INDUSTRIAL SCHOOL of an unusual character, connected with the Altoona High School, is the result of the desire of the Pennsylvania R. R. to improve the knowledge of many of the young men who enter its shops in that city. The equipment given to the school by the company is equal to that of the leading technical schools in the country and far in advance of that in many of them. Mechanical drawing occupies a considerable part of the student's time and is carried along through the whole four years' course; the shop work is apparently intended to give a general familiarity with the operations carried on in different portions of a large industrial establishment. The director of the school is Mr. A. E. Karlson, who has studied this branch of instruction not only in American schools, but also in those of Sweden, Germany and England. In planning the course and selecting the equipment for it he has had the assistance of the engineers of the Pennsylvania R. R. Co.

The Disposal of Strawboard Waste.

The disposal of the waste liquors resulting from the manufacture of strawboard or, as it is commonly called, pasteboard, is one of the important problems connected with the prevention of stream pollution in certain States. For each ton of strawboard manufactured in 1900 there was discharged about 65,000 gal. of waste liquor containing about 1,173 lb. of straw and mineral matter and 490 lb. of lime. The total waste discharged in 1900 amounted to approximately 10,239,710,000 gal. of liquor containing about 184,700,000 lb. of straw and mineral matter and over 77,000,000 lb. of lime. This was discharged by fifty-nine plants of various sizes, the principal factories being located within a comparatively small area. Indiana, Ohio and Illinois make about 80 per cent. of the strawboard produced in the country, and Indiana alone produces nearly 50 per cent. of the total. After these States come New York, Maryland and Michigan. As most of these mills are along small streams the resulting pollution is very apparent. The low selling price of the product, the great volume of waste water necessary and the fact that competition between strawboard and other forms of cheap board is active make it impracticable for the manufacturer to adopt any process involving heavy expenditures.



Pump and Alternator, Rocky Ford.

The problem of the disposal of these wastes was studied by Prof. R. L. Sackett, of Earlham College, Richmond, Ind., and the results of his investigation were made public in a bulletin published by the United States Geological Survey, and in abstract in the issue of The Engineering Record of June 11, 1904. During 1905 and 1906 the United States Geological Survey, through its division of hydro-economics and in co-operation with the sanitary research laboratory and sewage experiment station of the Massachusetts Institute of Technology, continued along new lines the work of Prof. Sackett. This more recent investigation was made by Mr. E. B. Phelps, from whose report, published by the Geological Survey, these notes have been taken. It is believed that the process now recommended as a result of the later investigations, consisting of a short period of sedimentation followed by mechanical filtration through sand without coagulants, will produce an effluent which can be discharged into small streams in considerable quantities without producing a nuisance. It is further stated that the cost of the entire process is sufficiently low to admit of its adoption wherever stream pollution is serious.

At present the method generally used by the manufacturers in treating this waste liquor is prolonged sedimentation in open field ponds. During the summer a very offensive fermentation takes place in the sludge, giving rise to objectionable odors and blackening the water. The plan followed is to hold the waste water in the ponds during the warm months until the cold weather relieves the situation and the increased flow of the stream permits a discharge of the surplus water stored. Among the objections to this process is the fact that the ponds are continually filling up with soft mud, which renders them useless either for sedimentation basins or other purposes. Another objection is that the accumulated sludge is held for years and slowly putrefies. The insoluble material in these waste waters is, when dry, entirely stable. The present system, therefore, is not only unsatisfactory from the economic side, but is wrong in principle, since it encourages putrefaction.

The results of the recent investigation, which included both laboratory and field experiments, indicate that the removal of the dissolved coloring and other organic matter and lime in the waste water in an economical way is impracticable; that by plain sedimentation a removal of the suspended material practically as good as the best removal observed with the use of a coagulant can be accomplished; that a sedimentation period of one hour is sufficient for the removal of about 60 per cent. of the suspended solids, a longer period increasing this removal but slightly, and that for the removal of the remainder of the suspended matter mechanical filtration through sand at a high rate, with some provision for removing the accumulated sludge from the surface of the filters, is the most feasible method.

The plan of treatment recommended is as follows: The waste water should be passed through a properly designed settling tank of such size that it will give a storage period of about one hour. A tank built on the principle of the Dortmund tank would be preferable to any other owing to its compactness and the possibility of continuous use. The tank should have a capacity of approximately 1,200 gal. for each ton of strawboard produced per day by the mill. The clarified water should pass from the sedimentation tank directly to the filters, which should be built in small units. The filters should have an available loss of head of at least 12 ft. and could be run at a rate of 100,000,000 gal. per acre per day. This would necessitate a filter area of approximately 16 sq. ft. per ton of strawboard produced daily, allowing an excess of 10 per cent. for repairs and washing. The effluent from the filters should be used again as wash water, both for the filters and in the plant.

The sludge from the sedimentation tank could be most expeditiously treated in filter presses. It would then be reduced to the form of fairly dry and hard cakes. It is believed that this material might be used in making a cheap substitute for papier-maché. It has some value as a fertilizer and its loose porous nature makes it particularly valuable for use on clay soils. Instead of being filter-pressed, the sludge might be discharged upon small areas of sandy soil and allowed to dry out by drainage and evaporation, the residue being removed from time to time, since no accumulation of the wet material should be allowed. The amount of land required for drying by the natural method under average conditions is roughly estimated at 1,000 sq. ft. per ton of strawboard produced daily. The process described will remove about 93 per cent. of the suspended organic solids and about 98 per cent. of the total suspended matter determined as turbidity. Experiments have shown that the effluent can be discharged into an equal volume of reasonably pure water without causing a nuisance.

A PECULIAR 51-STALL LOCOMOTIVE HOUSE has been built at 49th St., Chicago, by the Chicago & Western Indiana R. R. On account of the narrowness of the right of way the building has an elliptical shape. It is served by an 88-ft. turntable.

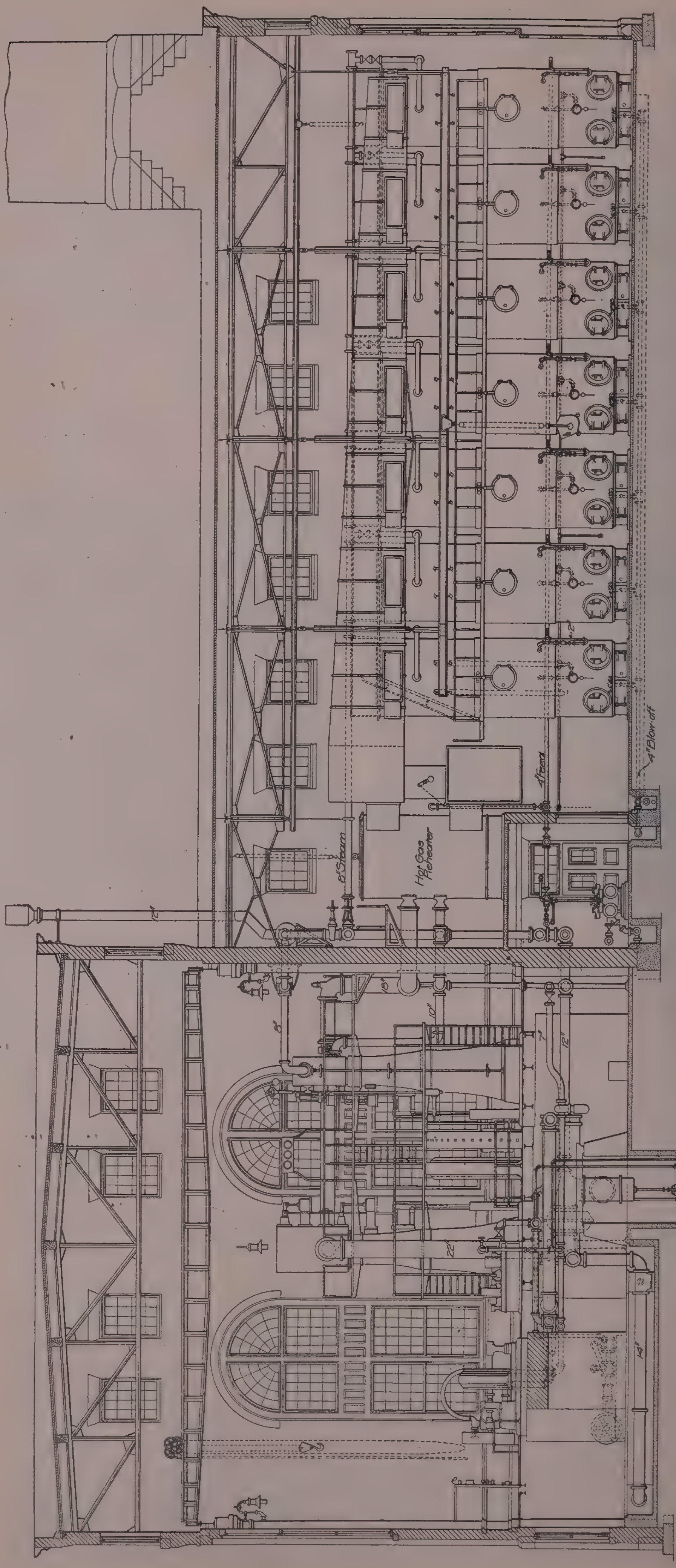
The Central Power Station at the Plant of Walter Baker & Co., Ltd.

The establishment of Walter Baker & Co., Ltd., at Dorchester, Mass., a suburb of Boston, embraces a number of mills engaged in the manufacture of chocolate and cocoa products. They are located at the crossing of Washington St. and the Neponset River, about 6 miles from the center of Boston, and embrace plants on opposite corners of the street and the stream, known as the Baker mill, the Webb mill, the Pierce mill and others. These mills are all large plants in themselves, which have until recently been operated by independent steam plants. In each case the engines were pairs of horizontal simple condensing and non-condensing engines supplied with steam by horizontal return tubular boilers, but it was some three years ago decided to have an economical central plant. For this purpose an extensive new power station has been built for the operation of all of the mills as a single unit, by means of which a maximum of economy and reliability might be attained.

The new power plant has been located apart from the mills, so as not to interfere with future extensions and additions to the mills, and so that the latter may not in any way be dependent upon power considerations. It is situated on the northerly bank of the Neponset River upstream from the mills, where the stream is several hundred feet in width and an ample supply of circulating water is available. The river water is of such a quality that it is used for feed for the boilers as well as for condensing. Convenient rail connections were also available at this point, for receipt of fuel and for handling machinery.

The plant is laid out on the cross boiler room principle, with a 60x80-ft. main engine room and a 57x96-ft. boiler house extending at right angles from one end. It is constructed of brick on concrete foundations throughout, and has a wooden roof supported on steel trusses. The architectural treatment of the exterior is simple yet productive of pleasing results, a feature of which is the liberal provision of windows for interior lighting. The roofs are covered with tarred paper and gravel and are nearly flat, draining to the outside with inside gutters. The interior is finished with common red brick painted with cold water paint in the boiler room, while in the engine room the finish is red pressed brick with limestone trimmings, by means of which an attractive interior has been secured. In the latter room the roof planking is concealed by sheathing of matched North Carolina pine. For the handling of machinery a 10-ton hand-operated traveling crane of 59-ft. span covers the engine room, traveling on 20-in. I-beam runways, which are supported upon ornamental pilasters in the wall construction at frequent intervals.

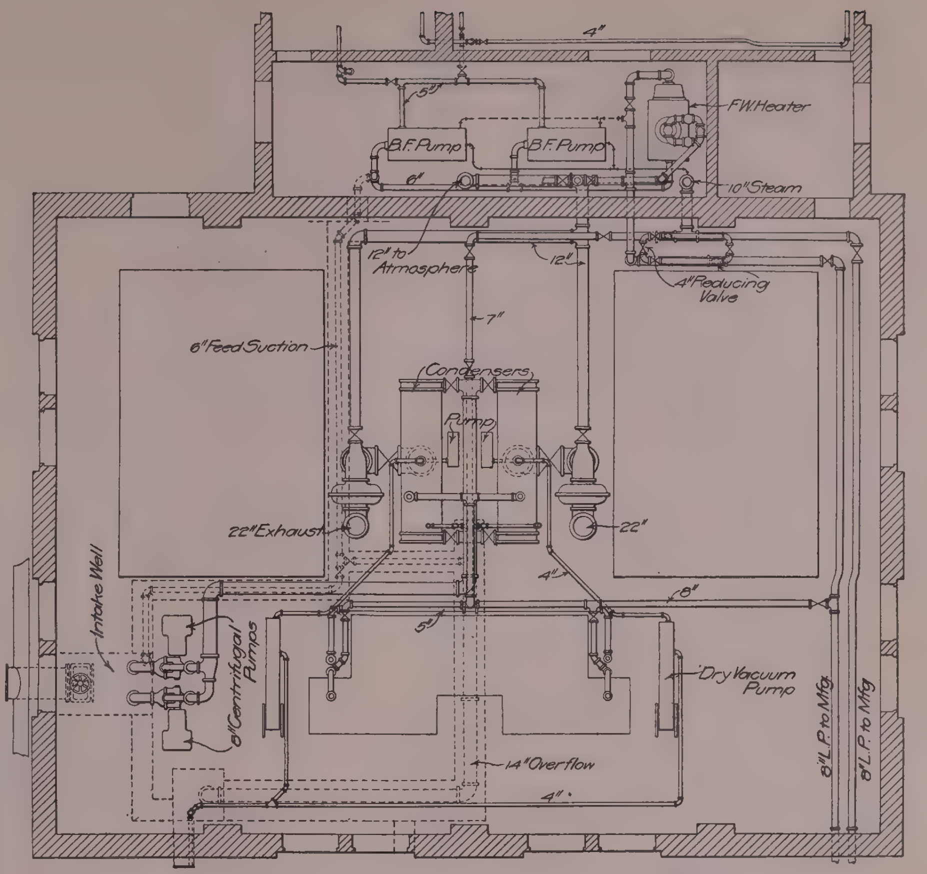
The plant has been designed for an ultimate capacity of 2,800 h.-p. in boilers, and 1,750 kw. in electrical generating machinery. The generating machinery is now all in place, but owing to the present requirements of the mill but a part of the steam generating capacity has been installed. The latter consists of vertical fire tube boilers in 200-h.-p. units, for which space has been provided in the boiler room for two rows of seven on either side, facing a central firing floor. Of these five are installed on each side at the end of the boiler room nearest the engine room. Special features of the steam plant are the use of the vertical fire-tube boilers, hot gas reheaters for reheating the intermediate stage steam from the compound engines, and flue gas economizers. The hot gas reheaters are located on an elevated platform at the engine room end of the boiler room, and the economizer in a 17x86-ft. annex to the southerly side of the boiler room. The boiler room proper is 40x96 ft. in



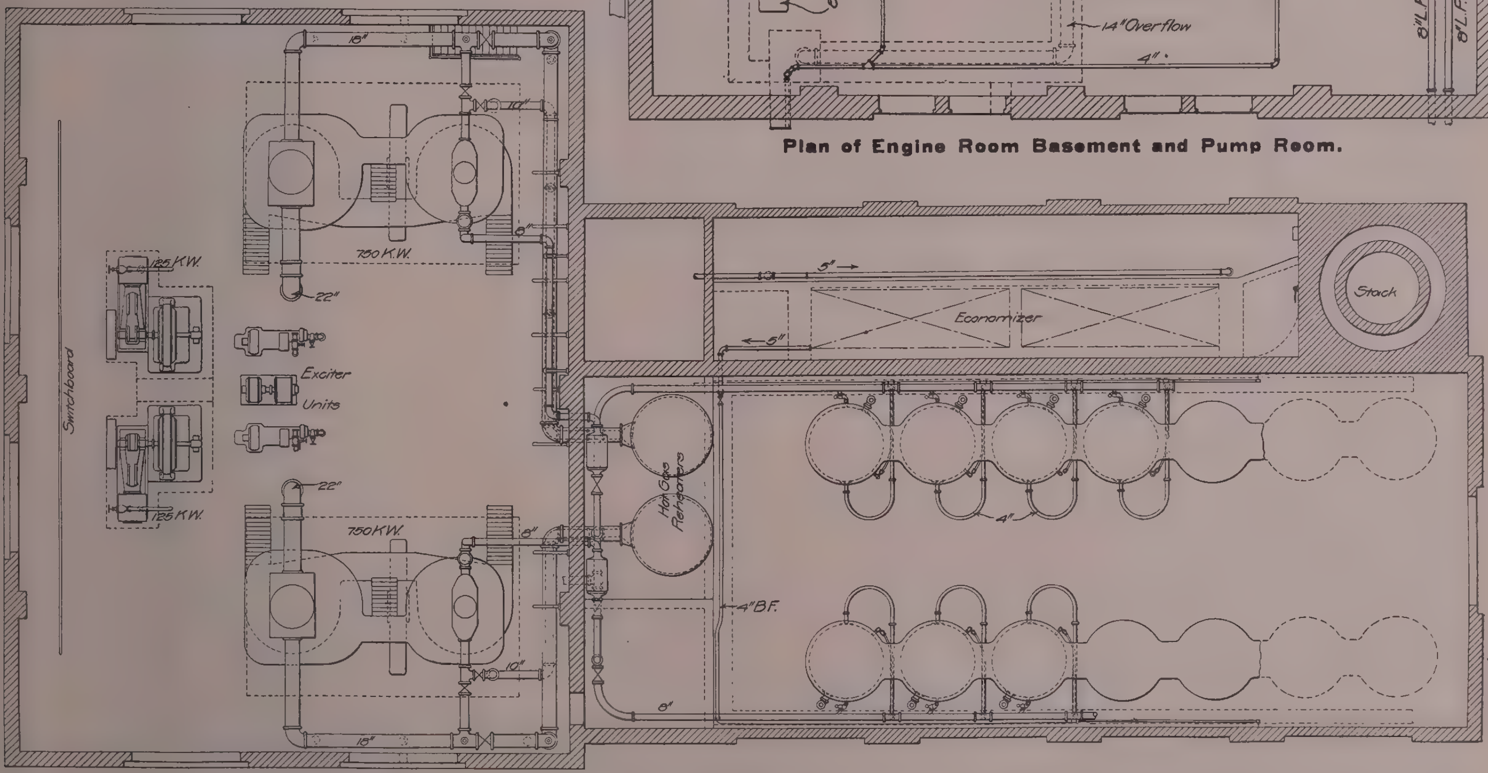
Longitudinal Section of the New Central Power Station of Walter Baker & Co., Ltd., Dorchester, Mass.

size and has a clear headroom of 36 ft. under roof trusses, there being no basement, although there is, under the elevated platform carrying the hot gas reheaters, a 13x42-ft. space with 12½ ft. clear headroom in which are located the boiler feed pumps and heater. The main engine room, which is 60x80 ft. in size, has a headroom under the roof trusses of 40 ft. to provide for vertical engines and the traveling crane above, and a basement with 10 ft. minimum headroom, accommodating condensing equipment and piping.

The boilers have 8-ft. shells standing 26½ ft. above the floor and have 308 2¼-in. tubes 15 ft. long, which present an effective water heating surface of 2,000 sq. ft. They are internally fired, having grates 7 ft. 4 in. in diameter with combustion spaces 6 ft. above the grate level. They are arranged for hand firing, coal being wheeled into the boiler room, which together with the handling of ashes, is greatly facilitated by the use of a central firing floor with rows of boilers on either side. The products of combustion are removed by a 200-ft. brick stack of 8 ft. interior diameter, which is located at the rear corner of the boiler house and is connected to the boiler smoke boxes by an overhead flue. The flue is of ⅛-in. steel suspended from the steel roof trusses, and ranges in size from 6x4 ft. at one end of the boiler room to 6x8 ft. at the other, where connection is made to the hot gas reheaters and thence to an economizer in the side addition to the boiler house, which extends back to the stack at the rear end. The connections from the flue to the boilers are 20x60-in. ducts, which connect with the side of the smoke boxes so that the entire top of the latter is left free for removal for access to the boiler tubes. From the large end of the flue two 40x80-in. connections are taken to the tops of the hot gas reheaters, from the bottom of which ducts of similar cross-section lead across into the annex building, to connect with the economizer. Both of the reheaters have 40x80-in. dampered by-passes and the economizer has a by-pass 8 ft. square formed under the concrete platform on which it is supported. The damper regulator is located at the point of connection of the economizer flue to the stack. The fuel supply for the plant will be stored in the yard outside the plant from which it will be brought to the boiler room by a telpherage system.



Plan of Engine Room Basement and Pump Room.



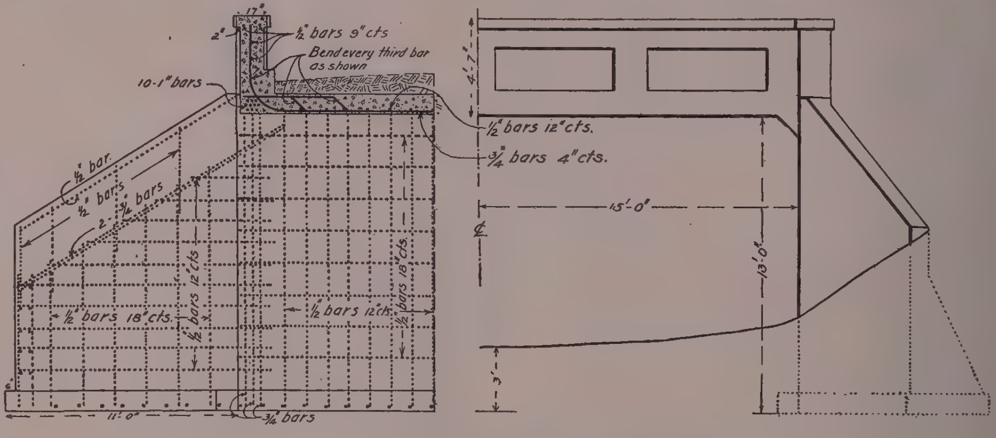
General Plan of the Plant, Showing Arrangement of Piping.

The boiler feeding equipment consists of two duplex outside end-packed feed pumps, a Cochrane feed-water heater and purifier and a Greene economizer, all of which have been installed of sufficient capacity provided for the total projected boiler plant of 14 boilers. The pump and the heater are located in the space underneath the elevated platform carrying the hot gas reheaters, and the economizer in the side addition to the boiler room, in which it is mounted on a concrete platform 8 ft. above the floor level and is 44 ft. in length. The feed pump suction connections are so arranged that the pumps will ordinarily draw through 6-in. suctions from the feed-water heater into which the condensation from the surface condensers is delivered by condensation pumps in the engine room basement. Make-up water is added from the city water system, from the circulating water or from the pond directly. The feed heater is supplied with steam from the exhaust delivery line from the small generating units and auxiliary steam-using machinery in the plant, to which it is connected inductively, low pressure steam being used in large quantities in the various mills for manufacturing purposes. The atmospheric relief connection from this low pressure line is made through the feed heater, a 6-in. relief line with two Schutte back-pressure valves connected in multiple being extended from the top to the 12-in. atmospheric exhaust riser, which serves the main engines of the plant. Watts reducing valves admit live steam to the low-pressure system as needed to maintain the pressure. The feed pumps deliver through a 5-in. line which extends to the economizer, with, of course, a by-pass connection direct to the boilers. The latter is a ring main of 4-in. brass pipe, which is laid out to encircle the boiler room, although at present it has been extended only so far as the boiler units now in place. The boiler branches are 2-in. brass connections which are brought from the main at the rear around to the front of the shells, through which the connection is made at a point about 2 ft. above the crown sheet, through two valves and a check valve, permitting access to the latter while the boiler is in service. A feature of the water connections to the boilers is a cold water main paralleling the ring feed main, from which a connection is made to each boiler for purposes of washing out and for filling up after washing, consisting of a 2-in. branch with stop and check valves; it is supplied directly from the city water main. Feed pumps have an emergency delivery connection to this main to permit feeding to the boilers in this way if anything should happen to the regular feed main. The boiler blow-off system consists of a 4-in. cast-iron blow-off main located in a trench at the rear of either row of boilers, which connect with a cross line of similar size at the forward end of the room, leading to discharge into the river alongside. The boilers have 2½-in. blow-off connections into the main, each consisting of two Morris blow-off valves connected in series. The economizer has a 4-in. blow-off connection which delivers into this line at a point near the side of the building while the feed water heater has an independent 4-in. blow-off line which is carried in the same trench to the point of discharge.

The high-pressure steam piping system consists of an 8-in. ring main in the boiler room, with 4-in. supply connections from each boiler, and has delivery connections to the main engines in the engine room, to the auxiliary machinery in the basement and to high-pressure delivery lines to the mills. The ring main is supported by hangers from the roof trusses at a level considerably above the tops of the boilers, the boiler branches consisting of double long radius bends from the steam nozzles at the front of the shell around the sides to the rear and up to the main. The two large vertical engines are supplied independently by 8-in. connections which are carried up at the division wall end of the boiler room to 30x42-in. receiver separators extending thence through the walls to the throttle valves. For the supply of the small horizontal engines, the auxiliary machinery and the high-pressure lines to the mills, a 10-in. line extends down into the engine room basement, from which an 8-in. branch extends to the mills and a 7-in. line to the auxiliary machinery and the horizontal engines. From the latter line steam is supplied also to the auxiliary equipments, including the dry air pumps of the condensing equipment, the condensation pumps and the boiler feed pumps.

The exhaust piping of the plant is simple. For the large engines there are direct 22-in. connections from the low-pressure cylinders through the floor to independent surface condenser units in the basement, in each of which connections there is an automatic relief valve, delivering to 12-in. lines to a common atmospheric riser and exhaust head above the boiler room roof. In each of the 22-in. exhaust connections from the engines there is inserted close to the condenser a 24-in. Cochrane oil separator, for the purpose of freeing the exhaust steam from lubricating oil entrained from the engine cylinders and thus preventing contamination of the boiler feed. The auxiliary exhaust system starts in an 8-in. connection to the intermediate stages of the large vertical compound engine units at points where the exhaust from the high-pressure cylinders enters the hot gas reheaters. From here the line drop into the pump room, where it is joined by the 3-in. exhaust from the feed pumps, and enters the Cochrane open feed-water heater through an oil separator. The line then extends into the engine room basement, where it is joined by an 8-in. main serving the horizontal generator engines, the exciter engines and the condensation pumps, and continues as an 8-in. line to the mill buildings for the low-pressure steam supply. There is a reserve connection to this low-pressure main from the live steam header in the engine room basement, consisting of a 4-in. Watts reducing valve with by-pass, thus permitting live steam to be added in case of deficiency of the exhaust. The low-pressure supply will ordinarily be furnished by the small engine units and the auxiliaries, the connections to the intermediate stages of the compound engines being for the purpose of adding to this supply without the use of live steam and still without sacrificing the advantages of operating the large engines condensing.

The two large units are vertical cross-compound engines built by the Allis-Chalmers Co., which have 22 and 48-in. cylinders with 48-in. stroke and operate at 120 r.p.m. They are both direct-connected to 750-kw. alternating-current Allis-Chalmers generators, which are mounted alongside of the 15-ft. flywheels on the engine shafts. The smaller generating units consist of simple horizontal 18x26-in. Watertown engines, direct-connected to Allis-Chalmers 125-kw. alternators and operating at 177 r.p.m. There are, in addition to the above, two De Laval steam turbine generator sets of 50 kw. capacity each, which together with a motor-generator set of equal capacity, are utilized for excitation purposes. The large engine units are supplied with steam by 8-in. connections from the boiler room main, while the small horizontal units have 5-in. connections and the turbines 3-in. connections from the basement steam main. The larger units exhaust, as above stated, to the condensing units in the basement, and the small engines to the low-pressure main in the basement. A noteworthy feature of the engine installation is the use of reheaters for compound engines, which are supplied with heat by the hot gases passing from the boilers to the stack. These reheaters consist of large cylindrical receivers, each fitted with a large number of 6-in. boiler tubes through which the hot gases are passed. They are located, as previously stated, on the concrete platform in the boiler room, elevated 13 ft. above the floor to facilitate connections to the flues and economizer. The smoke connections are led to both reheaters in multiple, while the steam connections are separate, one reheater serving for either engine. The latter connections consist of 10-in. lines from the exhaust side of the high-pressure cylinders, and 18-in. return lines from the reheaters to the admission side of the low-pressure cylinders, the steam being superheated about 30° Fahr. in passing through the reheaters under ordinary conditions. The oiling of the compound engines is accomplished by gravity from an elevated tank, the oil after passing the engines flowing by gravity to a filter in the basement, from which it is returned to the elevated tank again by a small duplex pump.



Standard Bridge of 30-Ft. Span, Illinois State Highways.

The condensing equipment consists of two Alberger surface condensers, one serving for each of the compound engine units, to which circulating water is supplied from the Neponset River by two electrically-driven Alberger centrifugal pumps. The condensers have separate 5¼x4¾x5-in. duplex condensation pumps located in a pit under the hot wells, which deliver to the feed water heater in the pump room. Each condenser is operated with a dry vacuum pump, which draws from the top of the condenser casing through 4-in. lines and discharges through a common 4-in. line ending in the circulation water overflow outlets. The 6x8-ft. intake well is depressed in the basement floor at the southeast corner next the river, 16 ft. below the engine room floor level, and has a connection to the river alongside by a 36-in. cast-iron pipe extending through the building wall foundation at that side. This intake pipe is provided with a valve so that the water can be shut off and the well pumped out and cleaned, and the well also has two sets of removable copper screens on the inner end of the inlet pipe.

The electrical generators deliver three-phase, alternating current at a potential of 600 volts, at which voltage current is transmitted directly to the mills for power and lighting purposes. The power feeders and the machines are controlled from a blue Vermont marble switchboard 60 ft. in length, which contains panels for the generators and feeders, and totalizing instrument panels. All circuits to the different mills have recording meters for measurement of the power supply to each department separately. The mills are operated entirely by induction motors, of which there are about 100 installed, ranging from 1 to 75 h.-p., and arranged for both individual and group driving. The lighting is done on the two-wire system at 110 volts, the voltage being reduced from the power feeder lines by transformers at each mill. The power feeders are carried to the mills through a steel bridge to the Baker mill, from which they pass over a bridge across the river to the Webb mill and through a subway some 200 ft. in length under Washington St. to the Pierce and other mills.

This power plant and the new power and lighting equipment of the various mills was designed and the construction superintended by Mr. F. W. Dean, mill engineer and architect, of Boston, Mass., formerly of the firm of Dean & Main.

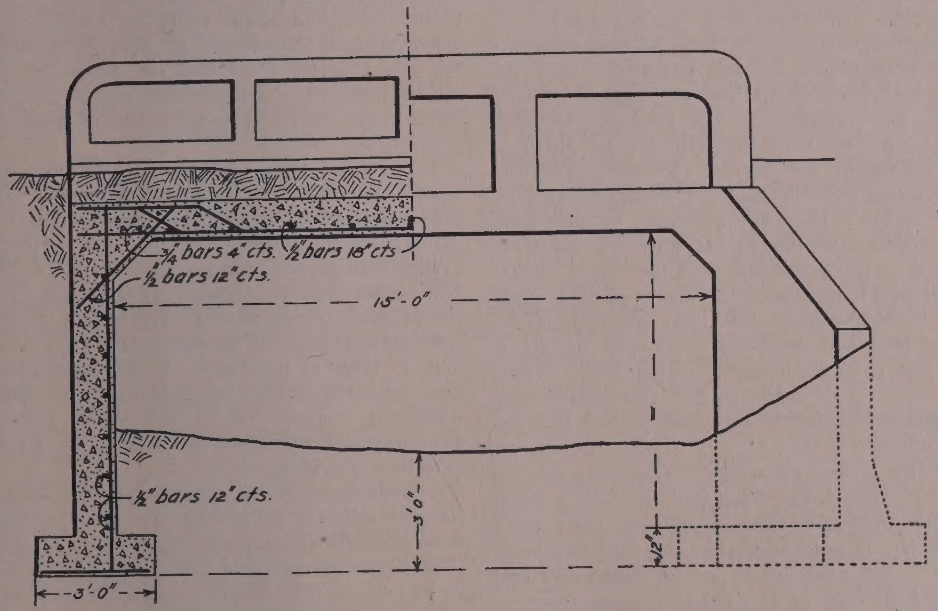
One of the Great Dikes of the Wachusett Reservoir of the Metropolitan water-works of Boston lost about 250 ft. of facing by a landslip on April 11.

Concrete Bridges Recommended by the Illinois Highway Commission.

The State Highway Commission of Illinois furnishes to the township and county highway officials throughout the State advice in regard to bridges as well as roads, and in many instances, at the request of the local authorities, the State Highway Engineer has supplied plans and specifications for the needed structures and has taken charge of the letting of contracts.

For highway spans of 50 ft. or less reinforced concrete structures should generally be used, according to the annual report of the Commission, from which these notes have been taken. In an accompanying illustration is shown a standard form of such bridge adopted by the Commission for spans up to 18 ft. and recommended as a substitute for short steel and wooden bridges.

A type of reinforced concrete bridge, recommended for spans of 25 to 50 ft., and for even longer spans where the stream bed affords good support for the falsework necessary to support the structure during its construction, is shown in another illustration. In this bridge the floor is reinforced most heavily in a direction parallel to the stream flow and the load is transmitted to the abutments by the reinforced concrete girders, which also serve as guard rails. A bridge of this type was designed for the township commissioners at Delevan, Tazewell County. It contains 90 cu. yd. of concrete and 8,600 lb. of steel reinforcement.



Standard Bridge of 15 Ft, Span, Illinois State Highways.

The bid received on this bridge was $1,125 if the contractor furnished everything. The commission supplied the crushed stone free of cost, which brought the cost of the bridge down to $995.

Mr. A. N. Johnson, State Highway Engineer, is in charge of the engineering work of the Illinois Highway Commission.

Municipal Ownership of the electric lighting plant of Wellesley, Mass., was undertaken in January, 1906. During the year the town spent $49,312.82 in reconstructing the system and installing new apparatus. Current is not generated by the town, but is purchased from the Edison Electric Illuminating Co. The rates charged are 14 cents per kilowatt-hour for lighting and 12 cents for power when current for the latter is measured by a separate meter. The minimum charge per meter is $1 per month, and a 10 per cent. discount is allowed on all amounts in excess of $1 if paid within a certain period.

Prevention of Freezing in Concrete by Calcium Chloride.

By Richard K. Meade.

Probably each winter finds more and more concrete work being done. The importance of protecting such work from freezing and thawing is well understood, and it is now the general practice either to heat the sand, gravel and water used in making the concrete or else to add salt to it. Heating the water and aggregate hastens the setting of the mortar and staves off the freezing, by the initial heat of the mixture, until after the concrete has hardened. In the other case the salt being dissolved by the water used in the making of the mortar, forms a brine which freezes at a lower temperature than does pure water. The first method is expensive, troublesome and in large undertakings almost an impossibility. The second method is, therefore, the one usually resorted to for preventing freezing.

Now it is a well-known fact that solutions of calcium chloride freeze at a much lower temperature than do solutions of salt of the same degree of concentration. For instance, a 20 per cent. solution of salt freezes at 7° F., while a 20 per cent. solution of calcium chloride does not freeze until the temperature falls 8° lower, or to 1° F.; calcium chloride should, therefore, be much more effective than salt in preventing the freezing of cement mortar. Additions of salt to concrete have no other beneficial effect than to prevent freezing, while calcium chloride in small percentages is known to often cause unsound cement to become sound and also to render cement mortar more impervious to water.

In view of these facts, it seemed an important matter to investigate the effect which calcium chloride exercises in preventing the freezing of mortar exposed to low temperatures. At the beginning of the cold weather of the present winter, therefore, the writer undertook a series of experiments along that line, the results of which follow.

Strength.—In order to investigate fully the strength of Portland cement mortars, with and without addition of calcium chloride, when exposed to cold weather, ten sets of sand briquettes of ten briquettes each were made up as follows:

Sets.	Cement.	Sand.	Calcium Chloride, Per Cent.
2	1	2	0
1	1	2	2
1	1	2	4
1	1	2	6
2	1	3	0
1	1	3	2
1	1	3	4
1	1	3	6

The sand used was standard crushed quartz and the cement was of a standard American brand, about two weeks old and normal in every respect. It passed both the steam and boiling tests and left a residue of 4 per cent. on a No. 100 test sieve. It took its initial set in 2 hours and its final set in 5 hours and 15 minutes.

The calcium chloride used was obtained from the Carbondale Chemical Co., Carbondale, Pa., and was marked Solvay Process Co.'s Chloride of Calcium and guaranteed by them to contain 75 per cent. anhydrous salt, $CaCl_2$.

Of the ten sets of briquettes, two, one 1:3 mortar and one 1:2 mortar, both containing no chloride, were tested in the ordinary standard manner, by leaving them in the laboratory for 24 hours under a damp cloth and then placing them in water for the balance of the 7 and 28-day periods, this being merely the standard test to determine the strength the cement was capable of developing under standard conditions.

The other eight sets were carried out of doors as soon as made. They were placed on a porch roof, on the northwest side of a building, and exposed to whatever the elements had in store for them. The morning after they were made they were covered with snow and this was cleared away to remove its protection from the wind. The range of temperature is shown in Table 1 for the entire 28 days. The "first day" is the day that the 1:3 sand briquettes were made and taken out of doors, and the temperature given as the maximum is that to which they were first exposed. The 7-day 1:3 briquettes were broken on the eighth day and the 28-day, 1:3 briquettes on the 29th day. The 1:2 sand briquettes were made and exposed on the second day and broken on the ninth day and thirtieth day, respectively.

Table 1.—Temperatures to Which Briquettes Were Exposed.

	Max.	Min.		Max.	Min.
1st Day...	35		18th Day...	24	14
2nd " ...	38	19	19th " ...	25	13
3rd " ...	35	18	20th " ...	17	5
4th " ...	23	15	21st " ...	29	—1
5th " ...	31	13	22nd " ...	27	10
6th " ...	12	—1	23rd " ...	27	3
7th " ...	15	—4	24th " ...	35	20
8th " ...	26	8	25th " ...	29	25
9th " ...	25	22	26th " ...	28	12
10th " ...	18	6	27th " ...	39	23
11th " ...	23	8	28th " ...	38	13
12th " ...	30	5	29th " ...	47	30
13th " ...	34	22	30th " ...	44	15
14th " ...	23	5	31st " ...	28	13
15th " ...	38	12	32nd " ...	26	13
16th " ...	43	30	33rd " ...	21	8
17th " ...	23	17	34th " ...	26	16

The 7-day 1:3 briquettes were exposed to temperatures as shown between the first and eighth days, and the 28-day 1:3 briquettes to the temperatures indicated between the first and twenty-ninth days, etc.

It will be seen that the effect of the addition of 2 per cent. of calcium chloride was to make the cement mortar exposed to the cold as strong as that kept in a warm room, 60° to 70° F. This is no doubt due to the fact that calcium chloride prevents the freezing of water to which it is added and so, when it is mixed with the cement, it is taken up by the water used to gauge the mortar, preventing the freezing of this water and consequently allowing the processes of solution and crystalization, which constitute the hardening of cement mortar, to go on without hindrance by the freezing of the water.

The power which calcium chloride can exert to prevent the freezing of mortar may be understood from the following explanation. About 10 to 15 per cent. of water is used in making concrete. If all the calcium chloride dissolves in this, and since it is very soluble there is reason to believe that most of it does, a 15 to 20 per cent. solution of the salt will be formed and the freezing point of such a solution is 14° to —1° F.

The maximum effect seemed to be reached with 2 per cent. calcium chloride, and this amount was sufficient to increase the strength of the mortar approximately one-third over that of mortar not

TABLE 2.—TENSILE STRENGTH OF MORTAR WITH AND WITHOUT CALCIUM CHLORIDE UNDER DIFFERENT CONDITIONS.

	Individual Breaks, 1:2 Mortar										Average	
Age of briquettes, days	7	28	7	28	7	28	7	28	7	28	7	28
No chloride, tested in laboratory	412	527	394	531	392	516	410	548	398	538	401	532
No chloride, outside exposure	314	409	323	402	318	387	307	400	303	391	313	398
2 per cent. chloride, outside exposure	404	500	416	516	430	502	399	511	421	521	414	510
4 per cent chloride, outside exposure	338	432	315	401	327	406	317	421	323	420	324	416
6 per cent. chloride, outside exposure	367	462	359	430	350	441	350	432	361	444	357	442
	Individual Breaks, 1:3 Mortar										Average	
No chloride, tested in laboratory	280	360	278	364	292	372	290	360	287	352	285	362
No chloride, outside exposure	190	305	207	293	220	280	217	310	214	302	210	298
2 per cent. chloride, outside exposure	404	500	416	516	430	502	399	511	421	521	414	510
4 per cent chloride, outside exposure	266	307	254	287	260	284	282	290	277	294	268	292
6 per cent. chloride, outside exposure	284	287	284	297	271	281	264	306	262	280	273	290

protected from freezing. The larger proportions of chloride did not seem to exercise the same influence as 2 per cent. This was no doubt because additions of both 4 per cent. and 6 per cent. caused marked quickening of the setting time of the cement used. It is a well-known fact that quick-setting cement does not show as high strength as the slow-setting. It is a curious fact, although well known, that up to a certain point additions of calcium chloride retard the setting of cement, but beyond this amount they have the opposite effect.

About a week after the first lot of briquettes was made, a very cold spell of weather came and it was deemed advisable to make up a new lot of briquettes and expose to this extreme cold. Four sets were made up of 1 : 3 cement and sand mortar containing respectively 0 per cent., 2 per cent., 4 per cent. and 6 per cent. calcium chloride. Sand, cement and moulds were all chilled to out-of-doors temperature and the water was drawn from the tap, in this experiment. The briquettes were then placed out of doors as soon as made. The temperature at that time being 5° F., or 27° below the freezing point of water. The temperature dropped to —1° F. that night. The temperatures to which these briquettes were subjected is shown in Table 1. They were placed out of doors on the fifth day and the seven day and twenty-eight day briquettes were broken on the twelfth and thirty-third days, respectively. The tensile strength of these briquettes is shown below in Table 3.

TABLE 3.—STRENGTH OF 1:3 MORTAR EXPOSED TO 5 DEG. TEMPERATURE AS SOON AS MADE.

Age.	7 Days				28 Days			
Chloride	0%	2%	4%	6%	0%	2%	4%	6%
Individual Breaks.	139	225	218	192	236	408	325	258
	142	215	226	174	215	388	328	270
	128	236	200	194	220	376	350	280
	140	221	202	180	218	378	342	263
	121	229	196	202	236	385	347	266
Average	135	225	208	189	225	387	338	267

It will be seen that the briquettes to which 2 per cent. calcium chloride had been added were more than two-thirds again as strong as those to which no calcium chloride had been added, showing that the colder the weather the greater the benefit will be derived by addition of calcium chloride.

In order to investigate the effect of alternate freezing and thawing upon the strength of cement mortars made with and without calcium chloride, four sets of cement mortar (1 of cement to 3 of sand) were made with 0 per cent., 2 per cent., 4 per cent. and 6 per cent. calcium chloride, respectively. These were placed out of doors as soon as made and allowed to remain out over night. The thermometer fell as low as 4° F. that night. In the morning they were brought into the laboratory and allowed to remain all day, the temperature reaching 72° F. while they were in the room, or a change in temperature of 68° F. Each night these briquettes were placed out of doors, and each morning they were brought in the house. In this manner they were exposed to alternate freezing and thawing daily for the whole of the first seven days and practically all of the 28 days. The strength of the briquettes so exposed is given in Table 4.

It will be seen that in this instance also the mortar containing 2 per cent. calcium chloride had about one-third greater strength than the mortar to which no chloride had been added.

TABLE 4.—STRENGTH OF 1:3 MORTAR, ALTERNATELY FROZEN AND THAWED.

Age.	7 Days				28 Days			
Calcium chloride	0%	2%	4%	6%	0%	2%	4%	6%
Individual Breakes.	247	318	325	302	313	379	359	351
	230	328	323	324	302	391	350	354
	244	317	313	318	316	396	358	323
	244	343	313	310	321	412	371	328
	231	340	306	304	290	414	362	352
Average	239	329	316	312	308	398	360	342

Color.—In order to determine the effect which calcium chloride would have on the color of the cement, and also to see if efflorescence occurred in concrete made with this, with a view to determining if calcium chloride could be used in making hollow concrete blocks during the winter time, small slabs of concrete 8 in. square were molded of 1 : 3 mortar. These blocks were allowed to dry out in the room, and also were alternately sprinkled and dried with a view to bringing out efflorescence. The slabs containing 4 per cent. and 6 per cent. calcium chloride, on drying out for the first time, showed considerable efflorescence; but this washed off when the slab was sprinkled and did not reappear. There were also apparent in the blocks small dark splotches with white borders, due no doubt to the caking of the chloride and consequently its not having been thoroughly disseminated through the mortar. This was overcome by dissolving the calcium chloride in the water used for the mixture. When this was done the slab of mortar made by adding 2 per cent. calcium chloride could not be distinguished from that containing none, after both had dried out. The slab containing calcium chloride, however, owing to its affinity for water, took longer to dry, and consequently looked darker, for the first week or two, than did the other.

Waterproofing Properties.—Some time ago the writer discovered that additions of calcium chloride helped to make mortar more impervious to water. In order to test this the slabs mentioned above were dried in the air for two weeks and placed on edge in a vessel containing about an inch of water and allowed to remain in this 24 hours. The slabs were weighed before being placed in the vessel and after being taken out and the surface water wiped off. The block containing no calcium chloride had absorbed 7.5 per cent. of its weight of water, while that containing 2 per cent. only 3.7 per cent. of its weight of water. This shows that calcium chloride lessens the permeability of mortar more than 50 per cent., or, in other words, that a block containing no calcium chloride will absorb twice as much water as one having 2 per cent. calcium chloride.

In this particular test, at the end of 24 hours, the slab containing no calcium chloride was wet all over while those having 2 per cent. and over had their upper edges still dry. The slab containing 4 per cent. calcium chloride absorbed 3.42 per cent. water and that containing 6 per cent. 3.40 per cent.

Soundness.—It is a fact well known that additions of calcium chloride will often render unsound cement sound. To several samples of unsound cement 2 per cent. calcium chloride were added and in each case the resulting mixture passed the steam and boiling tests perfectly.

Conclusions.—From the above tests and experiments the writer has come to the conclusion that additions of calcium chloride to mortar, which is to be exposed to cold weather, will prevent its freezing and allow it to develop its full strength. That mortar to which it has not been added, when so exposed, will not develop its full strength, and in some instances has even insufficient strength to admit of its being used in work of any importance or strength.

That it may be used in concrete blocks which are made in the winter time, adding to their strength and impermeability, without causing discoloration of, or efflorescence on, the blocks.

That the addition of 2 per cent. of calcium chloride will cause quick-setting cements to become slow-setting and often unsound cement to become sound. It is sometimes necessary to quicken the set of cement. When this is desired, calcium chloride, in the proportions of 4 or more per cent. of the cement, can most safely be used since caustic soda and carbonate of soda both may cause cement mortar to expand and crack.

Railway Water-Softening.

The provision of a suitable water supply for railway service is a problem which requires the joint efforts of civil and chemical engineering in a good many parts of the country. At the recent convention of the American Railway Engineering and Maintenance of Way Association, the report of the Committee on Water Service related wholly to water softening, and an abstract of its more important sections will be given in this article.

Two general types of softeners have been designed, the committee states, the continuous and the intermittent. In the continuous type, the natural water is introduced into the softener, passing through one or more chambers and finally flowing off into the regular storage tank, the sludge being precipitated to the bottom of the softener and drawn off by means of a valve from time to time, as necessary. In the intermittent type the water passes into settling tanks, from whence it is drawn off by pumping or gravity after reaction has taken place and the solids have been precipitated.

A modification of the intermittent type is used on some railroads by utilizing the regular storage tanks for settling purposes, but unless full time is given for reaction and settlement prior to the water being drawn off into locomotives, this form will not give the same economical results as either of the other forms. The control of reagents may be good, but a portion of the reaction will take place in the boiler, with a consequent increase in mud deposited.

Practical experience with the better-designed types of both the continuous and intermittent plants has shown that there is no difference in the efficiency of water-softening, providing the mechanical devices for control of the reagents are properly designed and the correct proportions given to the other parts of the plants.

Practice has demonstrated that between three and four hours is necessary for reaction and precipitation, depending largely on the temperature of the water and the composition of the scaling matter held in solution. Water taken from running streams in winter should have at least four hours' time. In all softeners there should be some form of filter for water to pass through before finally passing into the storage tank, in order to eliminate any flakes of scale or mud forming matter that still may be held in suspension.

At least three feet of the bottom of each settling tank should be reserved for the accumulation of the precipitates; therefore, in estimating the settling space needed and the capacity of settling tanks, the settling space should be considered as lying entirely above this reserved portion.

TABLE 1.—QUANTITY OF PURE REAGENTS REQUIRED TO REMOVE ONE POUND OF INCRUSTING OR CORROSIVE MATTER FROM THE WATER.

Incrusting or Corrosive Substance Held in Solution.	Amount of Reagent. (Pure.)	Foaming Matter Increased.
Sulphuric acid	0.57 lb. lime plus 1.08 lbs soda ash	1.45 lbs.
Free carbonic acid	1.27 lbs. lime	None
Calcium carbonate	0.56 lb. lime	None
Calcium sulphate	0.78 lb. soda ash	1.04 lbs.
Calcium chloride	0.96 lb. soda ash	1.05 lbs.
Calcium nitrate	0.65 lb. soda ash	1.04 lbs.
Magnesium carbonate	1.33 lbs. lime	None
Magnesium sulphate	0.47 lb. lime plus 0.88 lb. soda ash	1.18 lbs.
Magnesium chloride	0.59 lb. lime plus 1.11 lbs. soda ash	1.22 lbs.
Magnesium nitrate	0.38 lb. lime plus 0.72 lb. soda ash	1.15 lbs.
Calcium carbonate	1.71 lbs. barium hydrate	None
Magnesium carbonate	4.05 lbs. barium hydrate	None
Magnesium sulphate	1.42 lbs. barium hydrate	None
*Calcium sulphate	1.26 lbs. barium hydrate	None

* In precipitating the calcium sulphate, there would also be precipitated 0.74 lb. of calcium carbonate or 0.31 lb. of magnesium carbonate, the 1.26 lbs. of barium hydrate performing the work of 0.41 lb. of lime and 0.78 lb. of soda ash, or for reacting on either magnesium or calcium sulphate, 1 lb. of barium hydrate performs the work of 0.33 lbs. of lime plus 0.62 lb. of soda ash, and the lime treatment can be correspondingly reduced.

The proper capacities for settling tanks, measured above the space reserved for sludge, can be determined as follows: a = capacity of softener in gallons per hour; b = hours required for reaction and precipitation; c = number of settling tanks (never less than two); x = number of hours required to fill the portion of settling tank above the sludge portion; y = number of hours required to transfer treated water from one settling tank to the storage tank (y should never be greater than x).

Where one pump alternates between filling and emptying settling tanks, the time for filling and emptying the total number of tanks less one must equal the time for reaction and precipitation in that one, and x would equal y. As the capacity of the pump must be double the capacity of treating plant, the settling capacity in each tank would be $2ax = ab \div (c - 1)$.

For plants where the quantity of water supplied to the softener and the capacity of the plant are equal, the settling capacity of each tank is equal to ax. The total number of hours required to fill all the settling tanks should equal the number of hours required to fill, precipitate and empty one tank, as expressed by following equation: $cx = x + b + y$.

If $y = x$, $ax = ab \div (c - 2)$.

If $y = \frac{1}{2}x$, $ax = ab \div (c - 1.5)$.

Before considering the economical value of water-softening, it will be necessary to consider the reagents used and the quantity of reagents needed. Table 1 gives the quantity of reagents needed to remove one pound of incrusting or corroding matter from the water, also the effect on foaming quality of the water.

The first portion of the table considers the use of lime and soda ash as reagents, these being the cheapest and, at the present time, the most common in use. The great objection to the use of soda ash is the increase in the foaming tendency of the water. The latter portion of the table gives the quantity of barium hydrate required to treat the carbonates and sulphates of lime and magnesia. The foaming tendency of water is not increased by the barium hydrate treatment, hence its advantage over soda ash as a reagent.

Barium hydrate has no advantage over lime as a reagent to precipitate the carbonates of lime and magnesia and should not be considered as a reagent for these substances except in connection with the treating of water containing calcium sulphate. If there were no carbonates of lime and magnesia in the water, the combination of the calcium sulphate with the barium hydrate would produce calcium hydrate and barium sulphate. Calcium hydrate is soluble in water at ordinary temperatures to an extent of about 95 grains per gallon; therefore, the water would still be hard. Barium carbonate, if easily soluble, would react on the calcium sulphate and precipitate the incrusting matter. Barium carbonate is, however, only very slightly soluble, but can be produced in a form that will react on the calcium sulphate, by the combination of the barium hydrate with either magnesium or calcium carbonates, producing barium carbonate as one of the results of reaction, and if this reaction be carried out in the presence of calcium sulphate, the barium carbonate is not precipitated but reacts on the calcium sulphate before it can separate out of the solution. For each pound of calcium sulphate removed by such reaction there would be removed an amount of the calcium and magnesium carbonates which would have required 0.41 lb. of lime, and the lime treatment can be correspondingly reduced.

In calculating the quantity of reagents necessary where barium hydrate is used in place of soda ash, the full quantity of lime should be calculated for the calcium and magnesium carbonates, and from this should be deducted 0.33 lb. of lime for each pound of barium hydrate required on account of the calcium sulphate.

Knowing the analysis of a water, the pounds of incrusting or corrosive matter held in solution per 1,000 gallons can be obtained by dividing the grains per gallon of each substance by seven, or the parts per 100,000 by twelve.

The amount of incrusting solids going into boilers daily from any water station depends on the analysis of the water and the quantity of water used from that station, hence the minimum amount of scaling matter which will justify treatment cannot be stated in terms of analysis alone, but should be stated in terms of pounds incrusting matter held in solution in a day's supply. Neither can the composition of this minimum of scaling matter be definitely stated, since it requires a greater amount of reagents and much more expensive ones to treat the sulphates of lime and magnesia than to treat the same quantity of carbonates. Besides the scale-forming solids, nearly all water contains more or less free carbonic acid. Sulphuric acid is also found in waters, particularly in streams adjacent to coal mines. While this does not form incrusting matter, very serious trouble from corrosion will result from a small amount of this acid. In treating waters, the acids can be neutralized, and the incrusting matter can be reduced to at least 5 grains per gallon in most cases.

In estimating the benefits, due to the removal of incrusting solids prior to the introduction of the water into the boilers, it must be remembered that carbonates of lime and magnesia, without the presence of either the sulphates of lime and magnesia, do not form hard scale, but are precipitated in boiler as soft scale and mud, which can be removed for the most part by washing out and blowing off. A very small portion of either of these sulphates, in combination with the carbonates, will cause a hard, troublesome scale and increase the expense of boiler maintenance. With clean boilers, less fuel will be necessary to evaporate a given amount of water. Authorities differ regarding the increased amount of fuel required for a given amount of scale, but a conservative estimate seems to be about 10 per cent. increase for each 1/16-in. of scale.

The full saving of fuel will not be made if the foaming solids of the water have been increased during softening, as more water will have to be evaporated. Where matter is held in suspension in water, priming or foaming begins at an earlier concentration of matter in solution than if no suspended matter be contained in the boiler. In actual practice it is found that with a concentration of about 100 grains of foaming solids per gallon in locomotive boilers, trouble from foaming will begin. In order to avoid this trouble, the boilers must be blown off and new water admitted to take the place of this wasted water.

Water containing 10 grains of foaming solids per gallon will have reached the critical concentration on the tenth filling of the boiler; therefore, to reduce to the original concentration, the water should be completely changed, i. e., one-tenth or 10 per cent. of the water taken in the boiler would be blown off and wasted. For fifty grains per gallon of foaming solids, 50 per cent. would be wasted, as after one boiler full had been evaporated, the water would have reached the critical point.

From this it can be seen that the grains per gallon of foaming solids practically represent the percentage of water that must be wasted by blowing off, as the concentration reaches the critical point. In practice it would probably exceed this, as it would not be policy to blow off large amounts at one time when on the road, on account of the disadvantage of admitting large quantities of cold water to take its place.

If natural water containing 10 grains of foaming solids has this quantity raised to 20 grains by using soda ash as a reagent, there would be a minimum of 20 per cent. water wasted to keep it below the critical point, while only 10 per cent. would be wasted if treated with barium hydrate. Therefore, the grains increase per gallon of sodium sulphate caused by using soda ash as a reagent represents the minimum percentage point, while only 10 per cent. would be wasted if the water was not treated, or if barium hydrate was used as a reagent instead of soda ash. Therefore, the grains increase per gallon of sodium sulphate caused by using soda ash as a reagent represents the minimum percentage of water wasted in changing boiler waters over what would be wasted if water were not softened, or if barium hydrate were used as a reagent. The minimum waste would be represented by the total cost of pumping and treating this wasted water by soda ash plus the cost of the fuel required to raise this water from the temperature of feed water to the temperature of the water in the boiler.

For an increase of one pound foaming matter per thousand gallons of feed water, it would be the total cost of pumping and treating 70 gal. of water, and the fuel for heating the same to temperature of boiler water. For any other increase per thousand gallons of water, the minimum cost would be directly proportional to this.

With the foregoing points in view, the following equation is given to show the point where the benefits derived from treating the water will just balance the cost of treating: X = number cwt. (100 lb.) solids removed from water per annum. B = money value of benefits received from removing 100 lb. solids, comprising saving in boiler washing and repairs, saving in fuel and increased service received from locomotives, represented by the interest on the cost of the additional number of locomotives that would be required to perform the service rendered by locomotives using the soft water, if based on the performance prior to treating the water. C = cost per 100 lb. of solids removed to operate the plant, comprising additional cost of labor, additional cost of fuel or power, cost of chemicals, cost of current repairs. D = cost of plant installed. I = interest per annum on D. L = estimated useful life of plant in years. R = estimated value of materials recovered from plant after L years. $S =$ annual depreciation of plant, equivalent to a sum per year, which, if placed in a sinking fund at I rate of interest, would amount to $D - R$ in L years.

The benefits would just balance the cost when $XB = XC + I + S$.

The number of pounds solids removed daily to make benefits just equal the cost would be $(I + S) \div [3.65\ (B - C)]$. If more than this amount of solids is removed the plant will be profitable to the company.

Values for B can only be fixed for each particular case, as some of the matter held in solution is much more injurious than the same weight of other matters. The mechanical department of each railway should be able to approximate the values, knowing the proportions of the injurious matter in the water.

As shown by table 1, for every pound of calcium or magnesium sulphates removed by the use of soda ash as a reagent, the foaming solids of water are increased 1.04 and 1.18 lb., respectively.

Where there is already a considerable quantity of foaming matter in the water, or where there are large amounts of these scale-forming sulphates to be treated, this increase in tendency to foam may be very objectionable. Barium hydrate as a reagent does not increase the tendency to foam, hence its advantage over soda ash. In treating either calcium sulphate or magnesium sulphate, one pound of barium hydrate performs the work of 0.33 lb. of lime and 0.62 lb. of soda ash. As already explained, a portion of the carbonates of lime and magnesia will be precipitated in treating sulphate of lime, and the lime treatment correspondingly reduced. At the present time barium hydrate is a much more expensive reagent than soda ash, but owing to its superiority as a reagent, chemists are experimenting to devise practical methods of producing it at a cost that will not make it prohibitive. The amount that railroads can pay for this material above the cost of soda ash depends entirely on the value of keeping foaming solids down.

For any given water station the following equation would express relative equivalent values, for a given quantity of water: $A =$ pounds calcium sulphate to be removed. $B =$ pounds magnesium sulphate to be removed. $V =$ cost per pound lime. $X =$ cost per pound soda ash. $Y =$ cost per pound barium hydrate. $Z =$ value to remove $1.04\,A + 1.18\,B$ foaming solids from water.

Then the reagents required would be: For soda ash treatment: $(0.78\,A + 0.88\,B)$ soda ash, and $0.47\,B$ lime. For barium treatment: $(1.26\,A + 1.42\,B)$ barium hydrate less $0.41\,A$ lime.

Expense of reagents and wasted water would be: For soda treatment: $X\ (0.78\,A + 0.88\,B) + 0.47\,B\,V + Z$. For barium treatment: $Y\ (1.26\,A + 1.42\,B) - 0.41\,A\,V$. Then for equivalent values: $Y\ (1.26\,A + 1.42\,B) - 0.41\,A\,V = X\ (0.78\,A + 0.88\,B) + 0.47\,B\,V + Z$.

Letters to the Editor.

THE ILLINOIS HIGHWAY COMMISSION.

SIR: Your editorial in the issue of The Engineering Record of April 6, commenting favorably on the work done during the past year by the Illinois Highway Commission, cannot fail to meet with approval from many county engineers and others in this State who like myself have observed with regret the methods of road and bridge construction and repair pursued by many of our local highway officials. These men, though doubtless generally willing to spend the public money to the best advantage, seldom feel that the services of an engineer are required as a means of accomplishing this end, especially when the securing of such services involves a slight charge. Now that expert advice is supplied free by the State Highway Commission it is to be hoped that an improved condition of our roads and bridges will be noted. Such improvement is likely to be first apparent in our small highway bridges some of which as built in the past are marvels of architecture. Instead of lessening the opportunity for private practice in the State, the service rendered by the commission should tend to impress more strongly on individuals and small communities the value and economy of engineering service.

Yours truly, ILLINOIS ENGINEER.
Peoria, April 9.

EFFECT OF CLAY IN SAND FOR CONCRETE.

SIR: I am sending the enclosed correspondence, thinking that you might desire to publish same in your correspondence columns and invite a further discussion of this very important question.

Yours very truly, E. S. LARNED.
Boston, April 10.

[The first letter is from Mr. L. L. Bingham, ex-president of the Iowa Association of Cement Users, and reads as follows:

"I dislike to trouble so busy a man, but there was one point brought up at our recent State convention which I confess rather scared me. If the conclusion be correct I am very glad to be forewarned. If, however, it was not justified I want to be relieved from unnecessary apprehension.

"It was with regard to foreign matter in sand. You know a number of tests have proved the greater strength of briquettes in the making of which different percentages of clay or loam were added to the sand. . . .

"Iowa and Southern Minnesota are using rapidly increasing quantities of cement drain tile, most of them made from bank sand containing 1 to 6 per cent. of clay, some banks even 8 to 10 per cent.

"Mr. M. J. Reinhart, assistant at Ames, instanced a series of tests with different percentages of foreign matter, made by him some years ago with the usual result of greater strength. The unbroken briquettes were, however, left in a shallow curing pan containing water for several months, with the result that total or partial disintegration resulted in proportion to the amount of foreign matter they contained.

"What has been the general experience along this line? Not opinion but definite knowledge. What percentage of clay is it safe to have sand contain? Absolutely clean sand is seldom found. The cleaner, the better naturally, but ideal materials are seldom practicable.

"To be explicit, are we justified in using a drainage concrete sand containing, say, not to exceed 5 per cent. of clay, when cleaner is not readily obtainable? The fact of even greater percentages in concrete that has stood for years with apparently increasing strength in footings, foundations and reservoirs, would seem to make some other cause responsible for the result cited, but I want to be sure."

Mr. Larned's reply to this inquiry reads as follows:

"In considering the meaning of tests where clay has been added in different percentages to the sand, you must take into account both the character and size of the sand grains, the proportion used and the amount of water used, also the method of keeping the briquettes, either in air or water between the time of making and the application of the test load. While some experimenters have found that in certain sands they can use considerable additions of clay with good results, their determinations cannot be taken literally as applying to practical conditions.

"It is a well-known fact that clay, fine dead sand, even though siliceous, and other foreign materials, seriously retard the hardening of cement mortars and consequently would likewise affect concrete. If the sand be perfectly dry, as in the case of laboratory tests, and the clay also dry and finely pulverized, you can see that a more intimate and even mixture can be obtained than in the case where the sand may be moist and the clay occurs in lumps. The results are also effected by the degree of mixing and manipulation, which in the laboratory is carried to a greater refinement than it ever reaches in practical operations.

"If a moderately coarse sand be used and the proportion of cement added is not quite sufficient to fill the voids in the sand, it is conceivable that a small addition of clay, sufficient in addition to the cement to completely fill the sand voids, would result in a denser mixture and consequently increase the compressive strength of the mortar. This result is contingent, however, upon the sand and clay being dry when first mixed, and the cement thoroughly and uniformly distributed through the fine aggregate.

"Where clay is found in association with sand in a bank, it becomes a question of how the clay is contained; i. e., whether in the nature of silt uniformly distributed throughout the sand or in layers or strata of small or considerable depth. If it occurs in the latter form it naturally follows that it will be in the form of lumps throughout the sand, and ordinary mixing is not sufficient to break this up and distribute it uniformly throughout the sand voids, and in consequence weak spots will be found in the mortar or concrete made from such materials.

"If the sand grains and fine gravel be coated with clay, as is often the case, it will require a comparatively wet mixture and vigorous working to dissolve the clay sufficiently to enable the cement to bond with the sand and gravel surfaces, and even then results are more or less uncertain. The effect of clay depends upon its physical condition, or its state of division, whether in such a condition that the individual atoms can mingle with the mechanical mixture as a filler, or whether it is in a colloidal or state of semi-solution (gelatinous), such that it reacts on the total mixture, so as to prevent the bonding of the cement with the sand.

"It may be difficult to anticipate this in actual practice without laboratory experiments to determine the physical condition of the clay. This may be done by elutriation and testing that portion of the clay which cannot be drawn down within a certain period of time by sedimentation, and which remains in suspense, thus indicating its colloidal state, which prevents the actual bonding of the cement with the aggregate, and, therefore, setting of the concrete. I have in mind two instances of failure directly traceable to the condition last named, and upon washing the sand and gravel before use, good results followed.

"For sometime past, engineers and concrete specialists have recognized the importance of analyzing and testing the sand before use, even though it appears upon ocular examination to be above suspicion. If you will do this and test the sand as it occurs with cement, before use in any important work, you will avoid disappointment and sometimes complete failure. Clay in sand used for semi-dry concrete or cement sand blocks, or other cement products made of a semi-dry mixture, is more likely to give trouble and result in failure than where used in wet concrete mechanically mixed."

This subject is one of such general interest and importance that a discussion of it by readers of this journal would undoubtedly be of much practical value.]

THE AVERAGE WATER CONSUMPTION per day per inhabitant in Wellesley, Mass., during 1906 was 43 gal. The population of the town is about 6,000. All services are metered.